63-3-3

Portsmouth Naval Shipyard
Portsmouth, New Hampshire

Technical Report
PNS TEST T 319 029
SUPPLEMENTARY REPORT ON THE DEVELOPMENT OF ANALYSIS TECHNIQUES FOR SUBMARINE MACHINERY INSTALLATIONS BY MECHANICAL IMPEDANCE METHODS
BUSHIPS PROJECT S-F013-11-01, TASK 1352

MARCH 1963

J. E. SMITH
Project Engineer

Directed by
J. E. Smith

Report Prepared by
J. E. Smith

Approval Information

SECTION HEAD-CODE 246-C

BRANCH HEAD-CODE 246

DESIGN SUPERINTENDENT

Cover and 78 **sheets**

TABLE OF CONTENTS

ABSTRACT

By reference 1.1, this Shipyard was assigned the task of investigating a complex experimental vibrating system with respect to the effects of multiple degrees of freedom of translational motion on the accuracy of calculated coupled responses.

This task was part of the mechanical impedance studies work assignment for this Shipyard for Fiscal Year 1963.

It was found that the accuracy of the calculated coupled responses of the test system were not improved by including three (3) degrees of freedom of translational motion in the calculations and that the primary cause of response calculation errors are due to other causes; principally, errors in the measured mechanical impedance data.

Additional tests are currently being conducted with an improved instrumentation system designed to increase the accuracy of the mechanical impedance data used for computation purposes. The results of this work will be reported, when complete, by PTSMH NAVSHIPYD report T819-030.

TITLE: SUPPLEMENTARY REPORT ON THE DEVELOPMENT OF ANALYSIS TECHNIQUES FOR SUBMARINE MACHINERY INSTALLATIONS BY MECHANICAL IMPEDANCE METHODS

1. REFERENCES

1.1 BuShips ltr S-F013-11-01, Task 1352 Ser 345-291 of 30 August 1962 Mechanical Impedance, Fiscal Year 1963 RDT & EN; work assignment for.
1.2 PTSMH NAVSHIPYD Technical Report T819 023 of July 1962, Preliminary Report on the Development of Analysis Techniques for Submarine Machinery Installations by Mechanical Impedance Methods.

2. PURPOSE

The purpose of this test was to investigate the effects of considering three (3) degrees of freedom of translational motion on the accuracy of the calculated coupled response of a vibrating system. This investigation was directed toward resolving the questions posed by reference 1.2 on the probable causes of the errors observed in the calculated responses in that test. These errors were assumed to be caused either by the neglect of multiple degrees of freedom of motion of the test system or by errors in the impedance measurements used for the computations, or both.

3. CONCLUSIONS

3.1 The results of this test show that the observed errors in the calculated coupled responses of the test system were not,primarily, due to neglect of multiple degrees of freedom of translational motion. The addition of the excitation provided by the minor axes, y and z, did not produce a significant change in the accuracy of the response calculations over that found for the principal axis of excitation, axis x, acting alone.

3.2 The statistical analysis performed on the results of this test indicates that the primary cause of the response calculation errors was due to error in the impedance information used for the computations. This conclusion is supported by the results of the statistical analysis by frequency range. An examination of these results shows a consistent increase in the standard error of the calculations with increasing frequency. The mechanical impedance data shows that the systems behave, generally, as rigid bodies over the first frequency range, (20-140 cps), and in this range the calculated responses show a relatively small standard error. With the introduction of resonant and anti-resonant conditions at the higher frequencies the accuracy of the calculations is adversely affected.

3.3 A portion of the calculation error may still be due to the difficulty of resolving accurately the impedance information from the data sheets as discussed in reference 1.2. This effect may be important at the higher frequencies but it seems unlikely that it was the major cause of the calculation errors experienced in the middle frequency range of 140-1800 cps.

4. RECOMMENDATIONS

Based on the results of this investigation, it is recommended that:

4.1 The test program outlined in reference 1.1 for improving the accuracy of calculated coupled responses of vibrating systems be continued.

4.2 Effort be directed toward developing an improved impedance head-shaker combination capable of controlling or eliminating extraneous excitation forces during an impedance measurement in order that the accuracy of measured impedance data may be improved.

5. RESULTS

5.1 The results of this test are shown as superimposed calculated and measured coupled velocity response curves on pages 7 through 22 for the test system shown on page 23. These curves include calculated and measured responses for terminals 3, 4, 5 and 6 on the receiver for each of the three (3) mutually perpendicular axes (x, y and z) considered individually and for the combination of the three (3) axes acting simultaneously. It was found that there was no gain in calculated response accuracy when the system was calculated for three (3) degrees of freedom and when the system was calculated for the principal axis of excitation, axis (x), acting alone.

5.2 A statistical analysis of the measured versus the calculated responses of the receiver terminals is shown on pages 4 and 5. This analysis includes a breakdown of the calculations for the principal axis of excitation, axis (x), and the combined three (3) axes of excitation (x, y and z) by frequency range. This breakdown by frequency range shows a consistent deterioration in precision with increasing frequency and indicates the presence of error in the impedance data.

5.3 The results of the statistical analysis show that where a principal axis of excitation is present no significant improvement is obtained in either the correlation coefficient or the standard error by the consideration of three (3) degrees of freedom. A comparison of these values is shown in the following table:

RECEIVER TERMINAL	CORRELATION COEFFICIENT (20-5000 cps)		STANDARD ERROR (20-5000 cps)	
	X Axis	Comb. Axes	X Axis	Comb. Axes
3	0.867	0.890	8.1	8.1
4	0.860	0.847	7.4	7.4
5	0.799	0.809	8.8	8.6
6	0.846	0.860	9.1	8.7

6. PROCEDURE

6.1 For the investigation of the effects of considering three (3) degrees of freedom of translational motion on the accuracy of calculated coupled responses, the test system shown on page 23 was employed. This system consisted of a box beam with a permanently attached shaker for the exciter and a length of channel beam for the receiver. The exciter and receiver were connected at one (1) point by steel blocks. These steel blocks were permanently attached to the exciter and receiver and formed the three (3) mutually perpendicular surfaces upon which the mechanical impedance and free velocity data, shown on pages 26 through 78, were measured.

6.2 The measurement and test procedure employed for this system was identical to that used in the test of reference 1.2. Mechanical impedance and free velocity data were measured on the unconnected exciter and receiver. This data was used in computing the coupled velocity responses of the receiver terminals. These calculated coupled responses were compared with the measured values taken when the exciter and receiver were connected.

6.3 The computation procedure for the test system, shown schematically on page 24, consisted of calculating the response of the receiver terminals 3, 4, 5 and 6 for each of the pairs of mutually perpendicular axes terminals x, y and z connected alone and for the simultaneous connection of the perpendicular axes terminals. The calculations were conducted at 0.33 db frequency intervals from 20 cps to 5000 cps. A statistical analysis of these computed responses versus the measured responses was made for purposes of evaluation of the test results.

STATISTICAL ANALYSIS RESULTS

TERMINAL VELOCITY	FREQUENCY RANGE (CPS)	REGRESSION EQUATION	CORRELATION COEFFICIENT	STANDARD ERROR (db)
V3(x)	20-140	Y= 2.2 + 0.987X	0.950	2.1
	140-1800	Y=15.3 + 0.731X	0.557	9.8
	1800-5000	Y=19.8 + 0.626X	0.680	9.1
	20-5000	Y=13.3 + 0.801X	0.867	8.1
V4(x)	20-140	Y= 4.3 + 1.06X	0.847	3.9
	140-1800	Y=18.5 + 0.665X	0.627	8.4
	1800-5000	Y=19.6 + 0.522X	0.594	7.9
	20-5000	Y=10.4 + 0.817X	0.860	7.4
V5(x)	20-140	Y= 4.4 + 0.926X	0.789	6.7
	140-1800	Y=30.0 + 0.539X	0.564	7.9
	1800-5000	Y=28.7 + 0.453X	0.476	10.8
	20-5000	Y=11.8 + 0.799X	0.799	8.8
V6(x)	20-140	Y= 7.4 + 0.938X	0.868	3.9
	140-1800	Y=32.9 + 0.459X	0.440	9.0
	1800-5000	Y=18.9 + 0.524X	0.578	11.1
	20-5000	Y= 9.9 + 0.853X	0.846	9.1
V3(y)	20-5000	Y=57.3 + 0.116X	0.111	16.4
V4(y)	20-5000	Y=53.8 + 0.134X	0.165	14.4
V5(y)	20-5000	Y=50.3 + 0.373X	0.407	13.3
V6(y)	20-5000	Y=55.1 + 0.176X	0.157	17.0

STATISTICAL ANALYSIS RESULTS (Cont'd)

TERMINAL VELOCITY	FREQUENCY RANGE (CPS)	REGRESSION EQUATION	CORRELATION COEFFICIENT	STANDARD ERROR (db)
V3(z)	20-5000	Y=44.7 + 0.437X	0.423	15.3
V4(z)	20-5000	Y=42.6 + 0.400X	0.383	13.4
V5(z)	20-5000	Y=30.6 + 0.707X	0.735	9.5
V6(z)	20-5000	Y=48.9 + 0.316X	0.370	16.3
V3	20-140	Y= 6.9 + 0.910X	0.864	3.3
	140-1800	Y= 8.9 + 0.828X	0.672	9.8
	1800-5000	Y=12.4 + 0.690X	0.680	8.9
	20-5000	Y= 5.1 + 0.912X	0.890	8.1
V4	20-140	Y=19.7 + 0.686X	0.548	6.1
	140-1800	Y=18.0 + 0.686X	0.744	6.9
	1800-5000	Y=24.5 + 0.412X	0.446	9.6
	20-5000	Y=13.8 + 0.754X	0.847	7.4
V5	20-140	Y=12.2 + 0.836X	0.765	7.1
	140-1800	Y=33.4 + 0.488X	0.610	7.4
	1800-5000	Y= 5.5 + 1.018X	0.676	9.6
	20-5000	Y= 7.4 + 0.849X	0.809	8.6
V6	20-140	Y=11.3 + 0.875X	0.883	3.8
	140-1800	Y=30.7 + 0.479X	0.548	8.4
	1800-5000	Y= 8.4 + 0.810X	0.609	11.3
	20-5000	Y= 9.7 + 0.846X	0.860	8.7

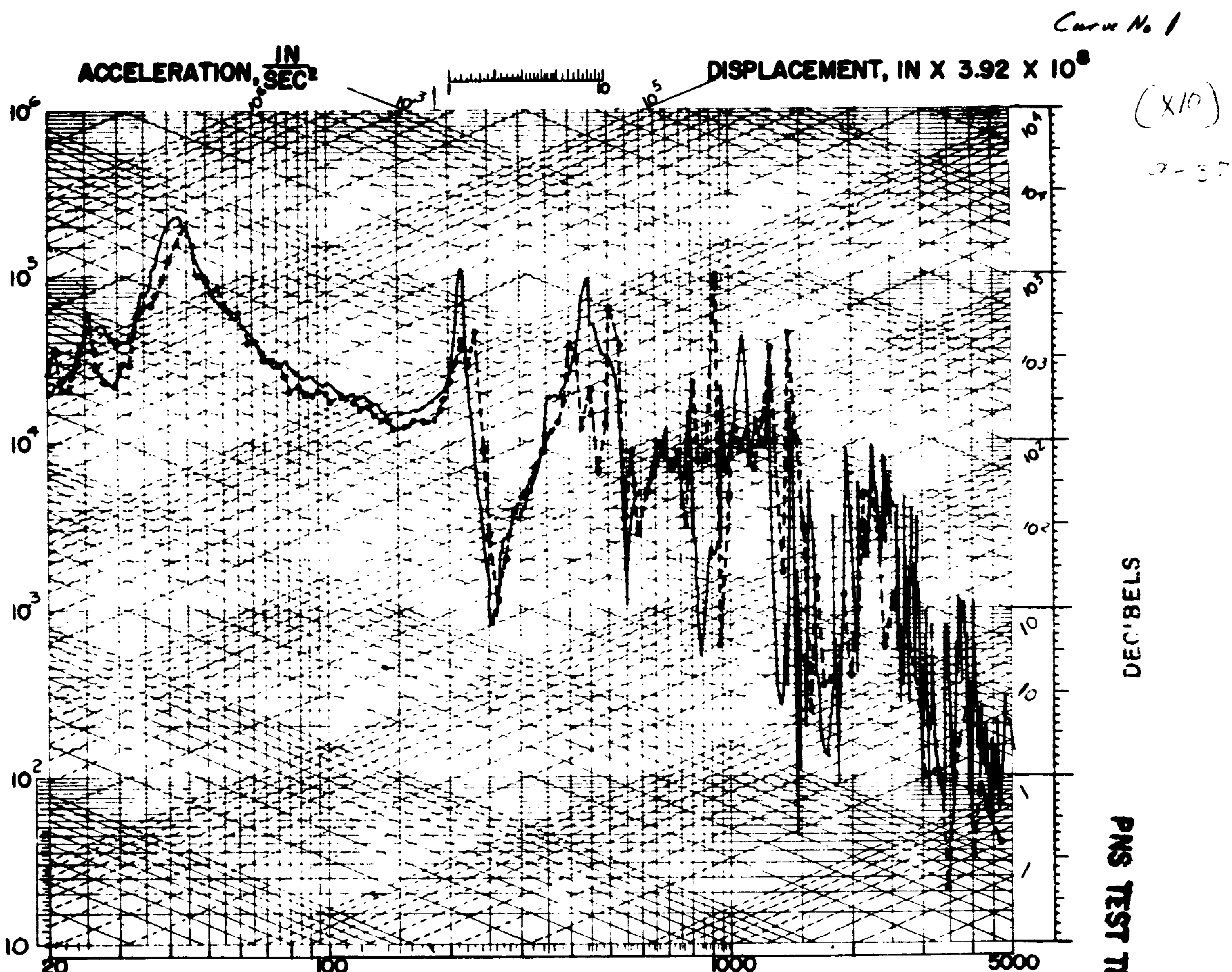
NOTE: Y = Expected measured value (vdb) Required regression equation; Y = X
X = Calculated value (vdb)

—CALCULATED VELOCITY RESPONSE INDEX— SINGLE CONNECTION, THREE DEGREE OF FREEDOM SYSTEM							
VELOCITY	PAGE	VELOCITY	PAGE	VELOCITY	PAGE	VELOCITY	PAGE
$V_{3(x)}$	7	$V_{3(y)}$	11	$V_{3(z)}$	15	V_3	19
$V_{4(x)}$	8	$V_{4(y)}$	12	$V_{4(z)}$	16	V_4	20
$V_{5(x)}$	9	$V_{5(y)}$	13	$V_{5(z)}$	17	V_5	21
$V_{6(x)}$	10	$V_{6(y)}$	14	$V_{6(z)}$	18	V_6	22

NOTES:

1. THE NOTATION $V_{N(n)}$ INDICATES THE VELOCITY RESPONSE OF RECEIVER TERMINAL N INDUCED BY EXCITATION ALONG THE (n) AXIS ONLY AND THE NOTATION V_N INDICATES THE VELOCITY RESPONSE OF RECEIVER TERMINAL N INDUCED BY THE SIMULTANEOUS EXCITATIONS IN THE THREE (3) MUTUALLY PERPENDICULAR DIRECTIONS x, y AND z.

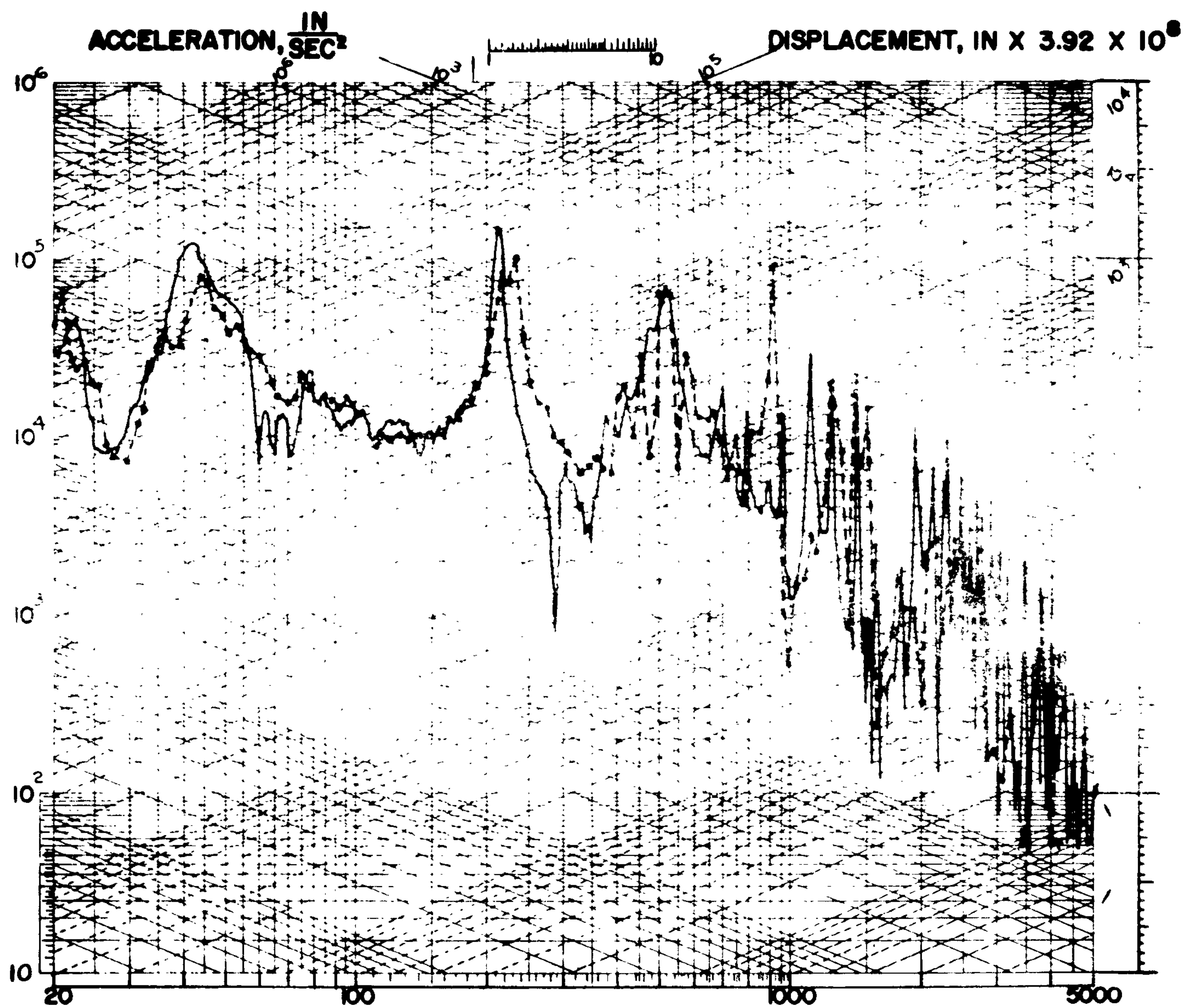
2. EACH VELOCITY RESPONSE CURVE SHOWS THE MEASURED VELOCITY FOR THE TERMINAL AS A SOLID LINE, (——), AND THE CALCULATED VELOCITY AS A DASHED LINE, (-•-).



Curve No 1
ACCELERATION, IN/SEC²
DISPLACEMENT, IN X 3.92 X 10⁸
(X10)
VELOCITY, IN/SEC X 10⁶
DECIBELS
FREQUENCY, CPS
20
100
1000
5000
10⁶
10⁵
10⁴
10³
10²
10
PNS TEST T819 029

$V_{3(x)}$

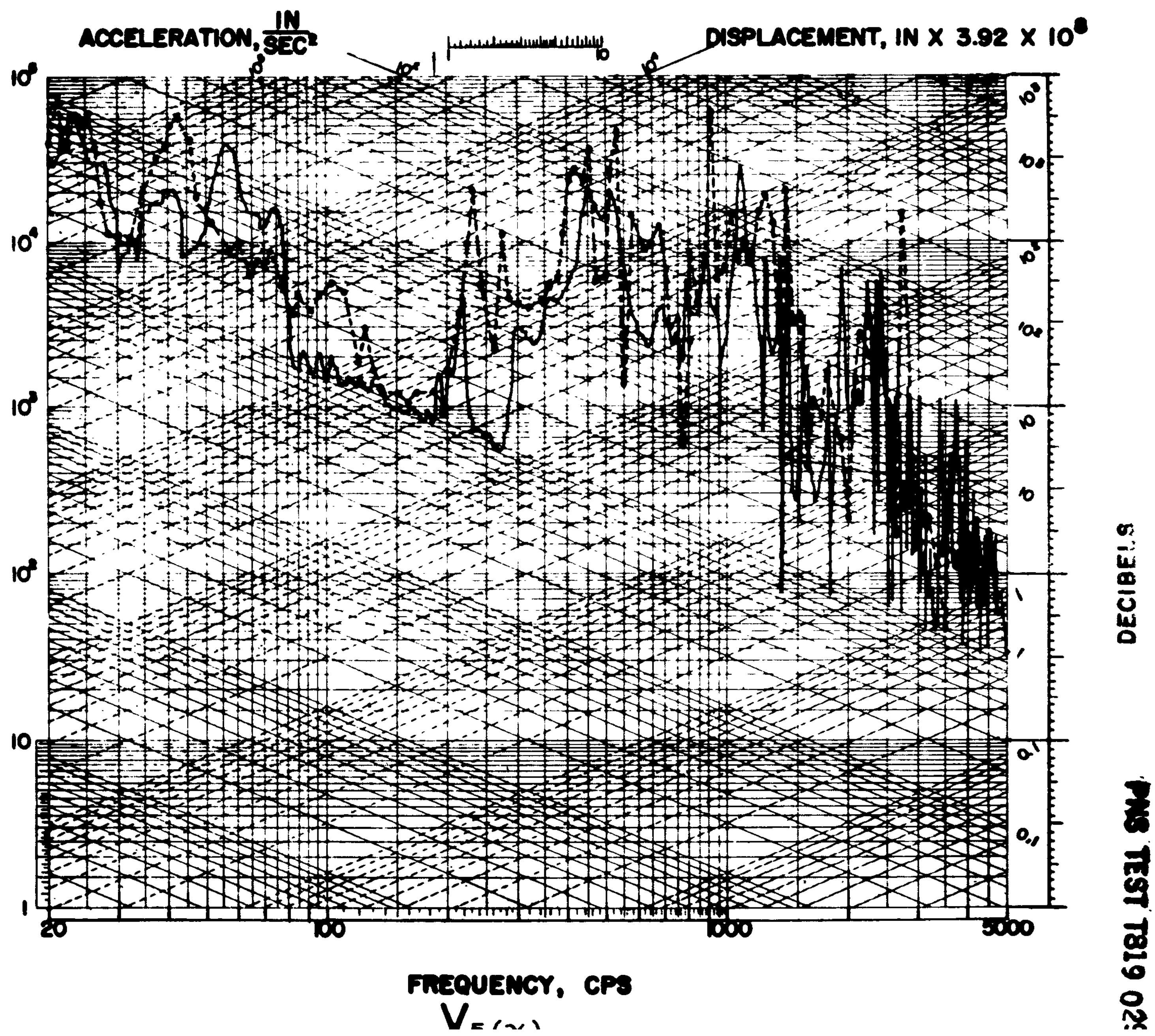
7



$V_{4\ (x)}$

5 (x10)

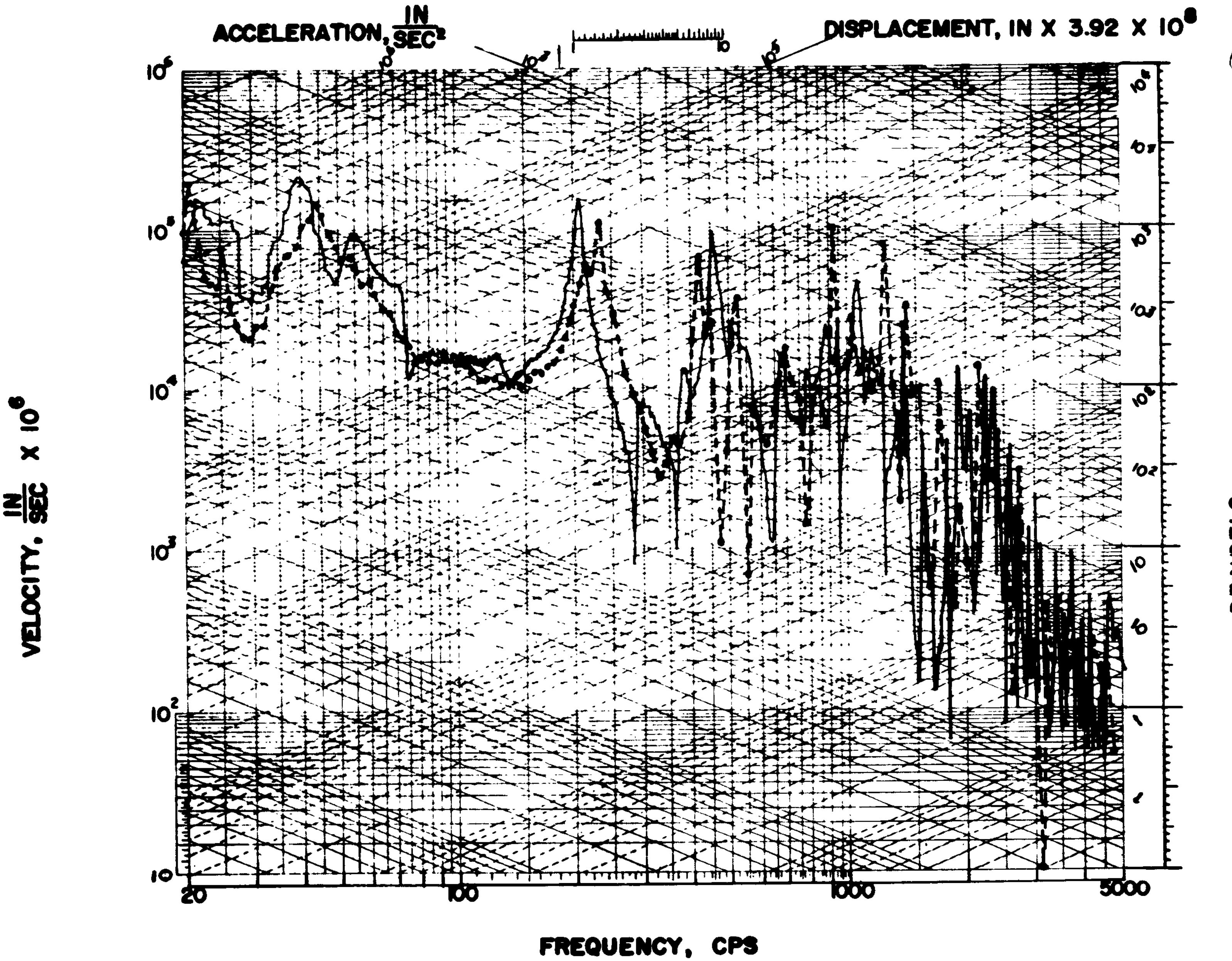
PNS TEST T819 029


9
1-3
ACCELERATION, IN/SEC²
DISPLACEMENT, IN X 3.92 X 10⁸
VELOCITY, IN/SEC X 10⁶
FREQUENCY, CPS
DECIBELS
20
100
1000
5000
10⁵
10⁴
10³
10²
10
1
PNS TEST T819 02
6
IND - PNS - 1749 (NEW 5-62)

13

(X 10)

12-37



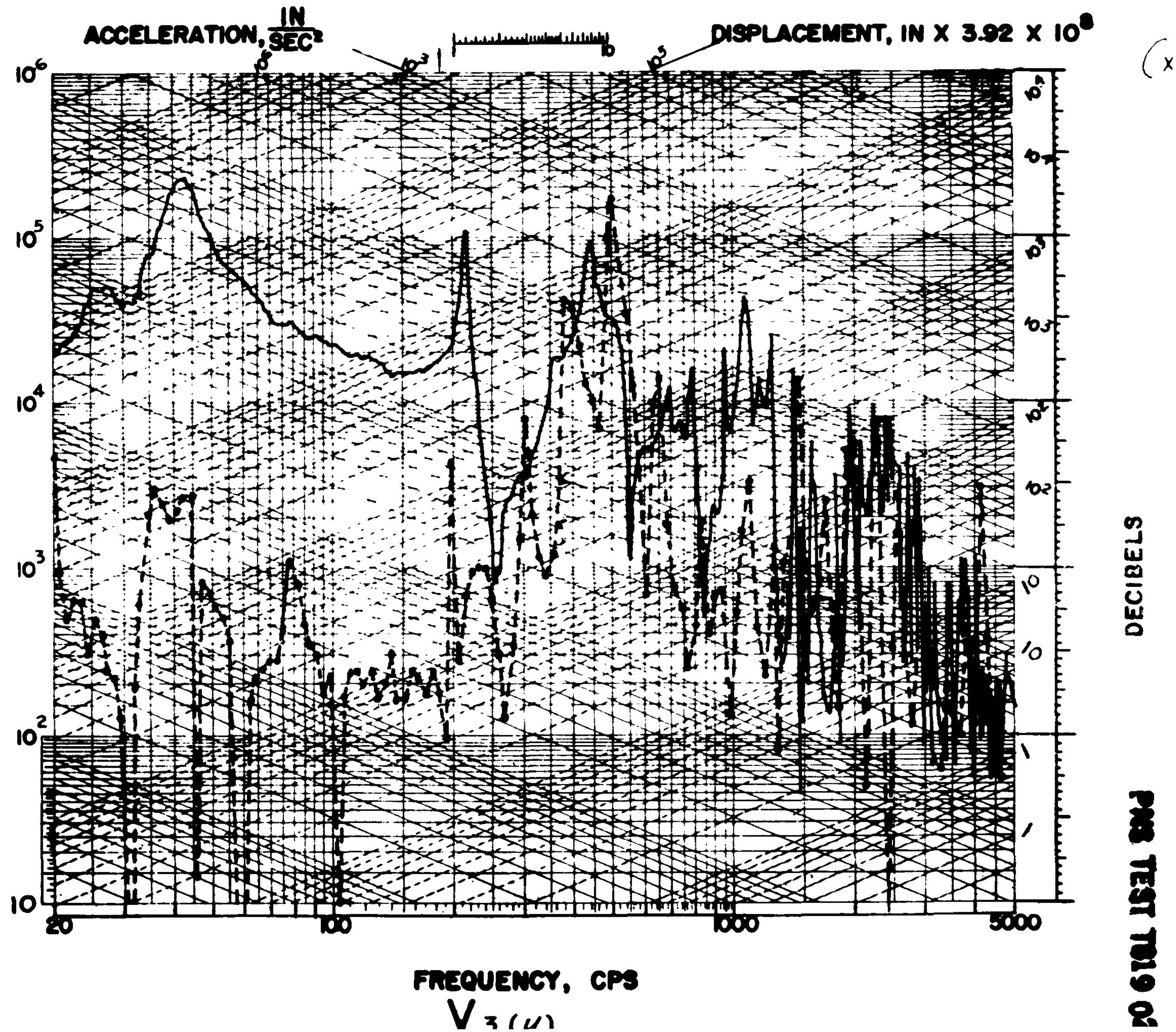
$V_{6(x)}$

PNS TEST T819 029

2

(x 10)

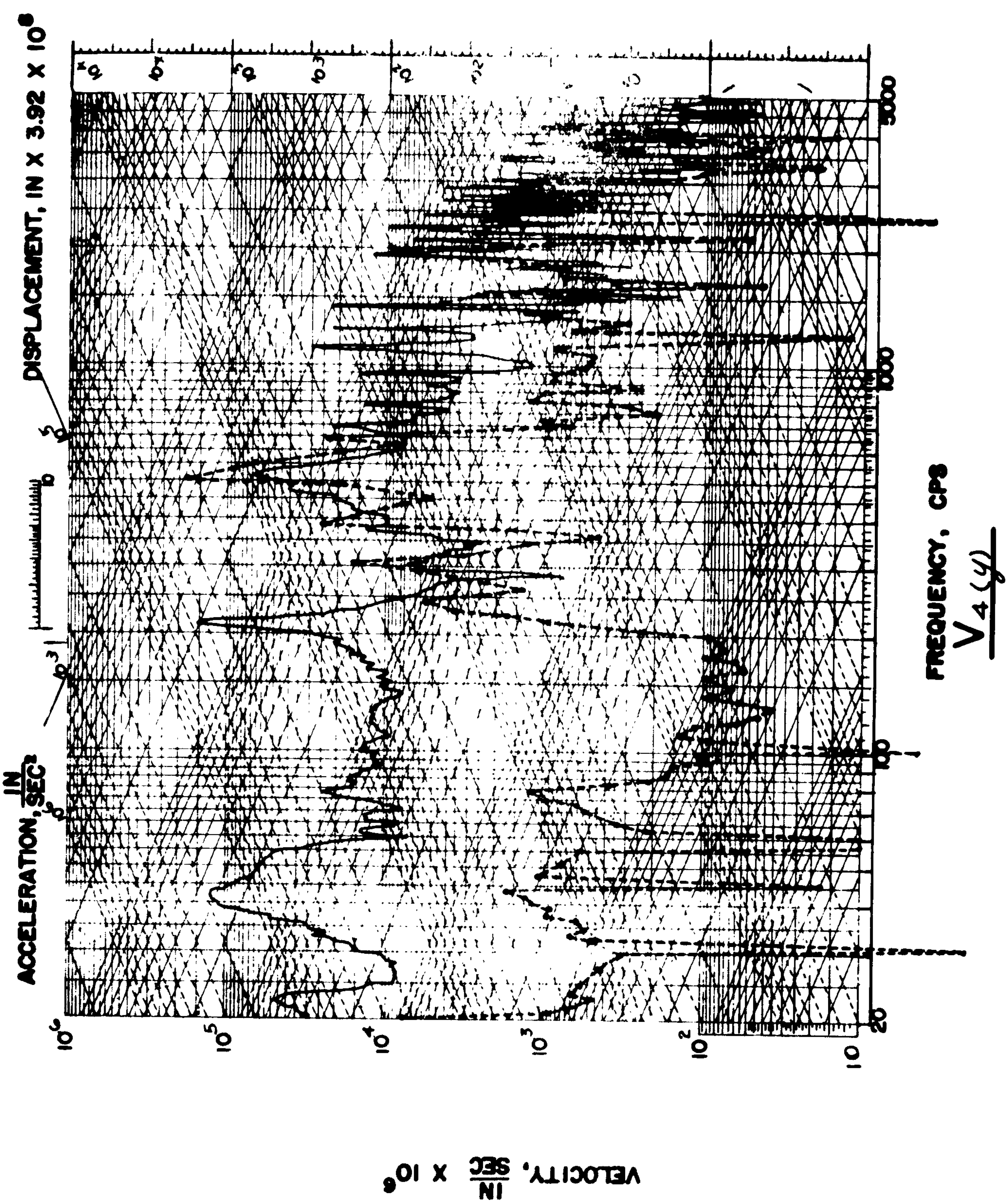
9-38



$V_{3(u)}$

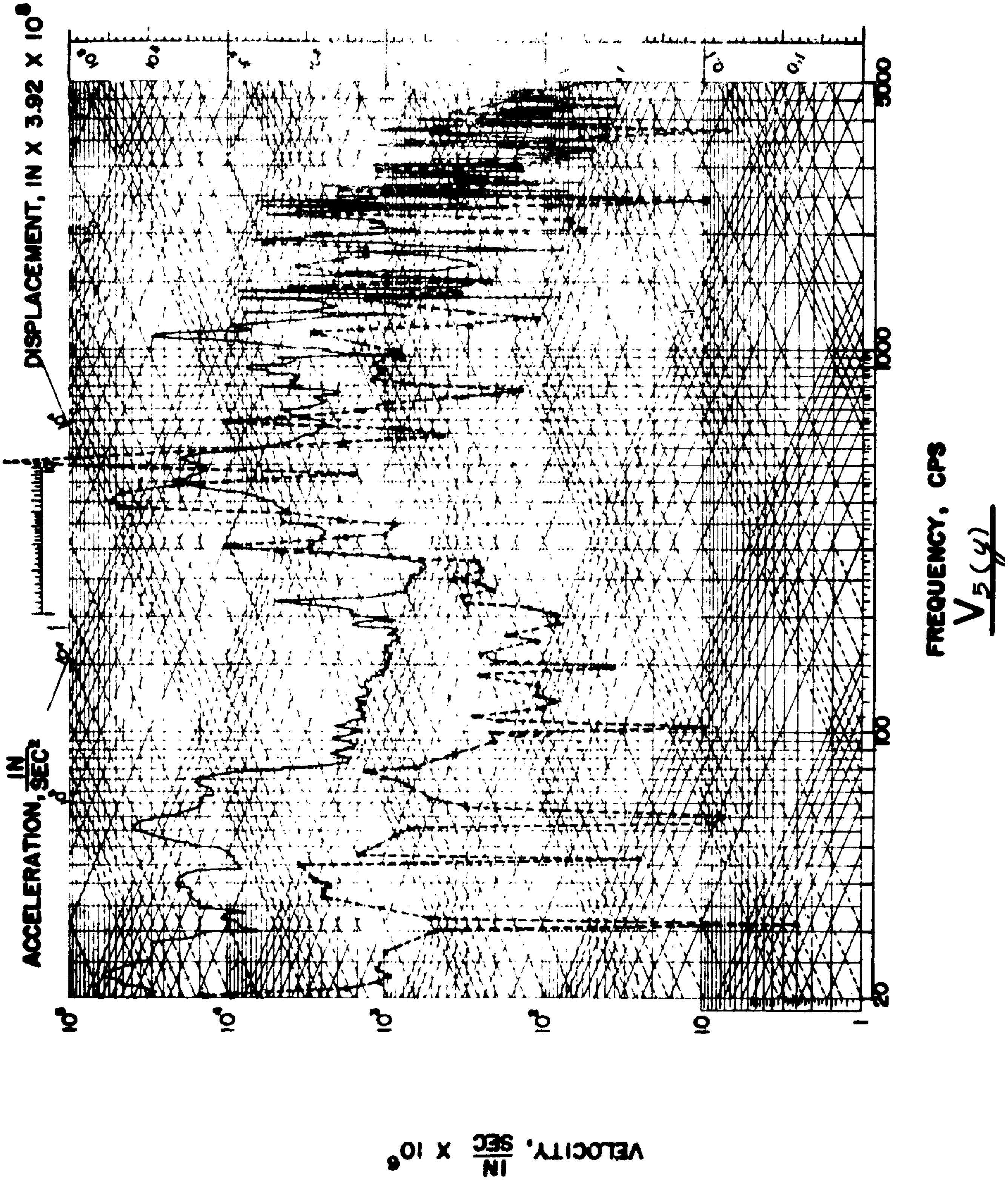
PNS TEST T819 02

6

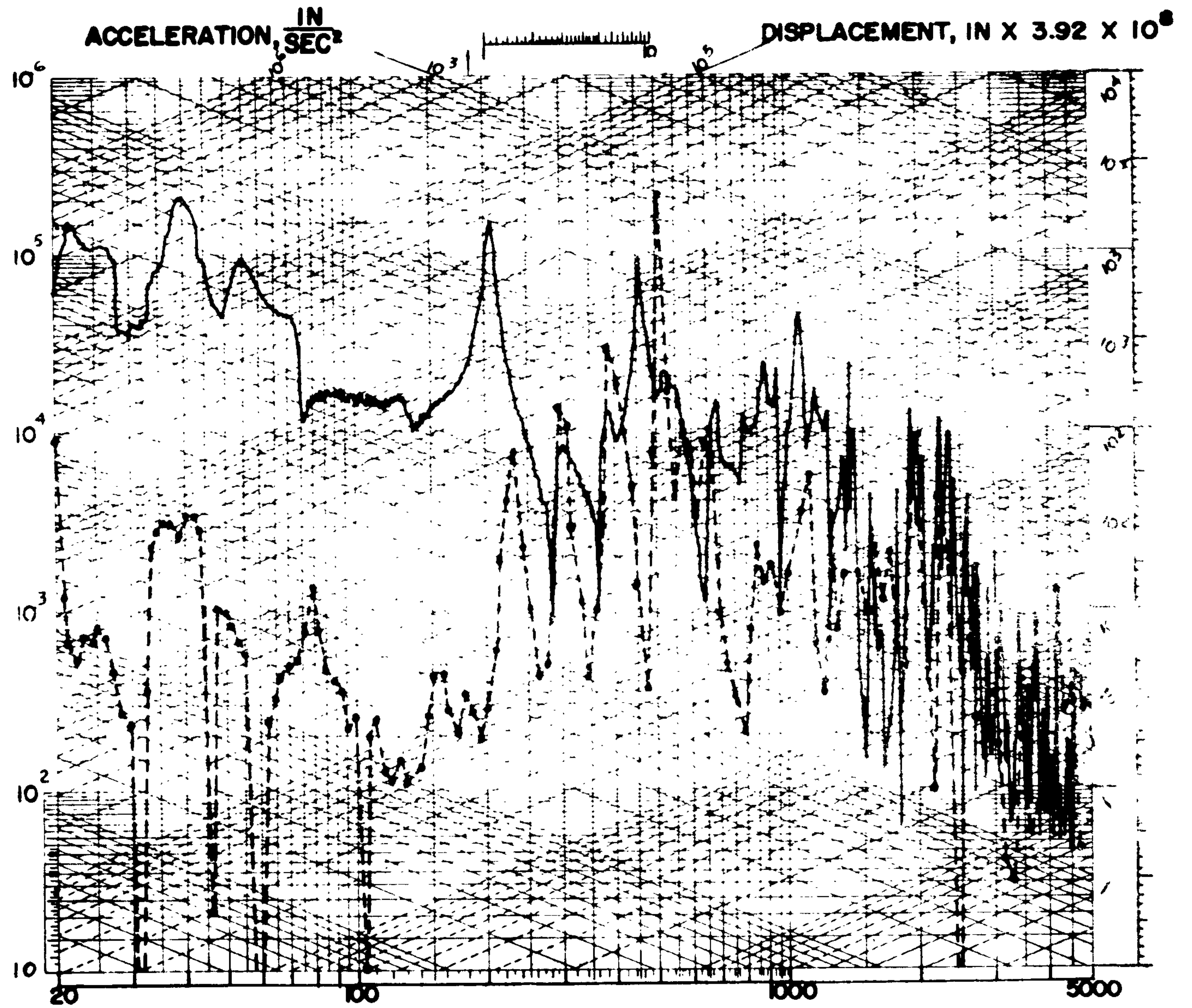

ACCELERATION, $\frac{IN}{SEC^2}$
DISPLACEMENT, IN X 3.92 X 10^8
FREQUENCY, CPS
$V_4(y)$
VELOCITY, $\frac{IN}{SEC}$ X 10^6
20
100
1000
5000
10^6
10^5
10^4
10^3
10^2
10

10

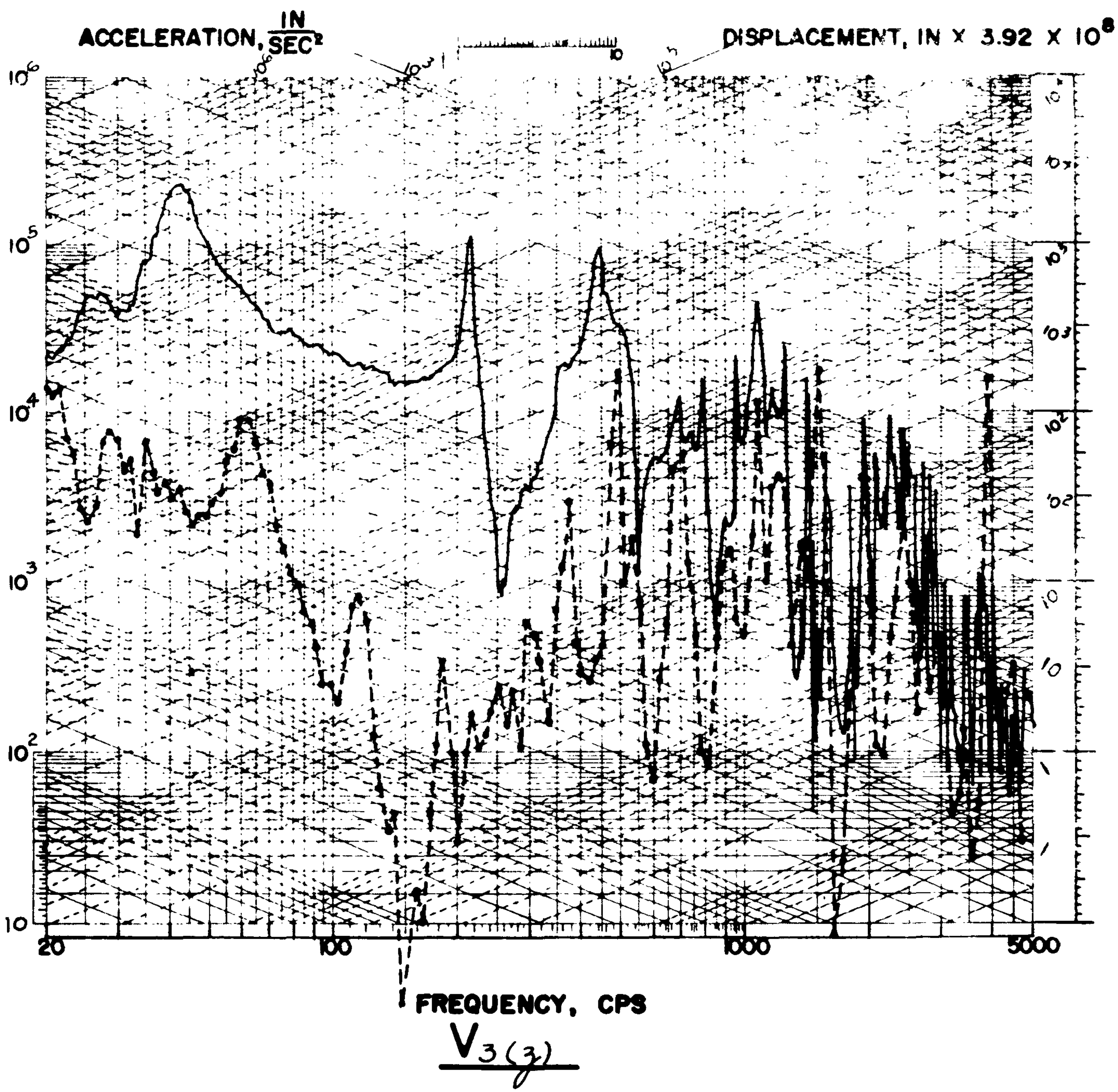
PNS TEST T819 029



14


ACCELERATION, IN/SEC²
DISPLACEMENT, IN X 3.92 X 10⁸
VELOCITY, IN/SEC X 10⁶
FREQUENCY, CPS
10⁶
10⁵
10⁴
10³
10²
10
20
100
1000
5000

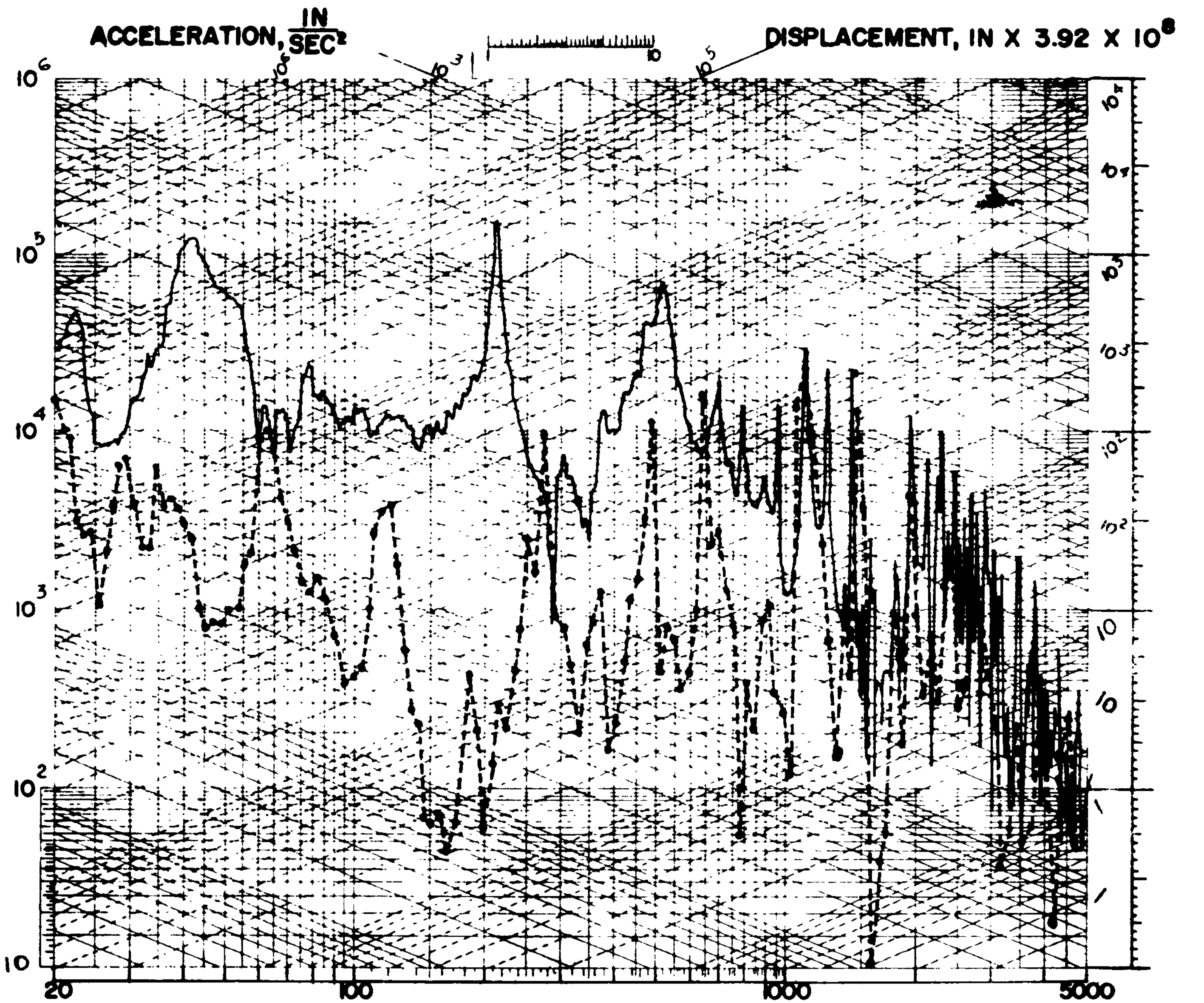
$V_{6}(y)$


ACCELERATION, $\frac{IN}{SEC^2}$
DISPLACEMENT, IN × 3.92 × 10⁸
VELOCITY, $\frac{IN}{SEC}$ × 10⁶
DECIBELS
FREQUENCY, CPS
20
100
1000
5000
10⁶
10⁵
10⁴
10³
10²
10

$V_{3(3)}$

7

10-39



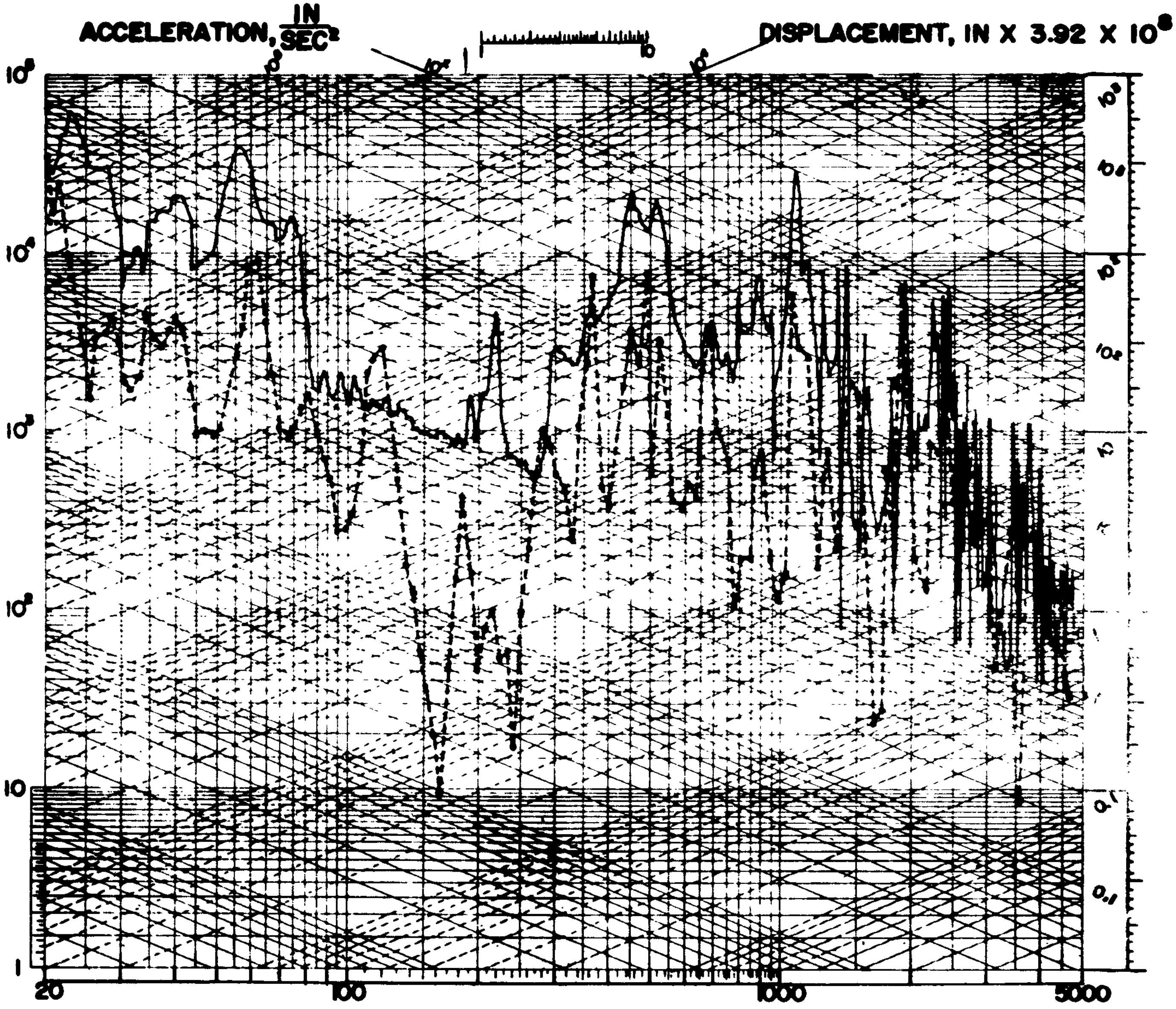
$V_{4\,(3)}$

PNS TEST T819 029

16

11

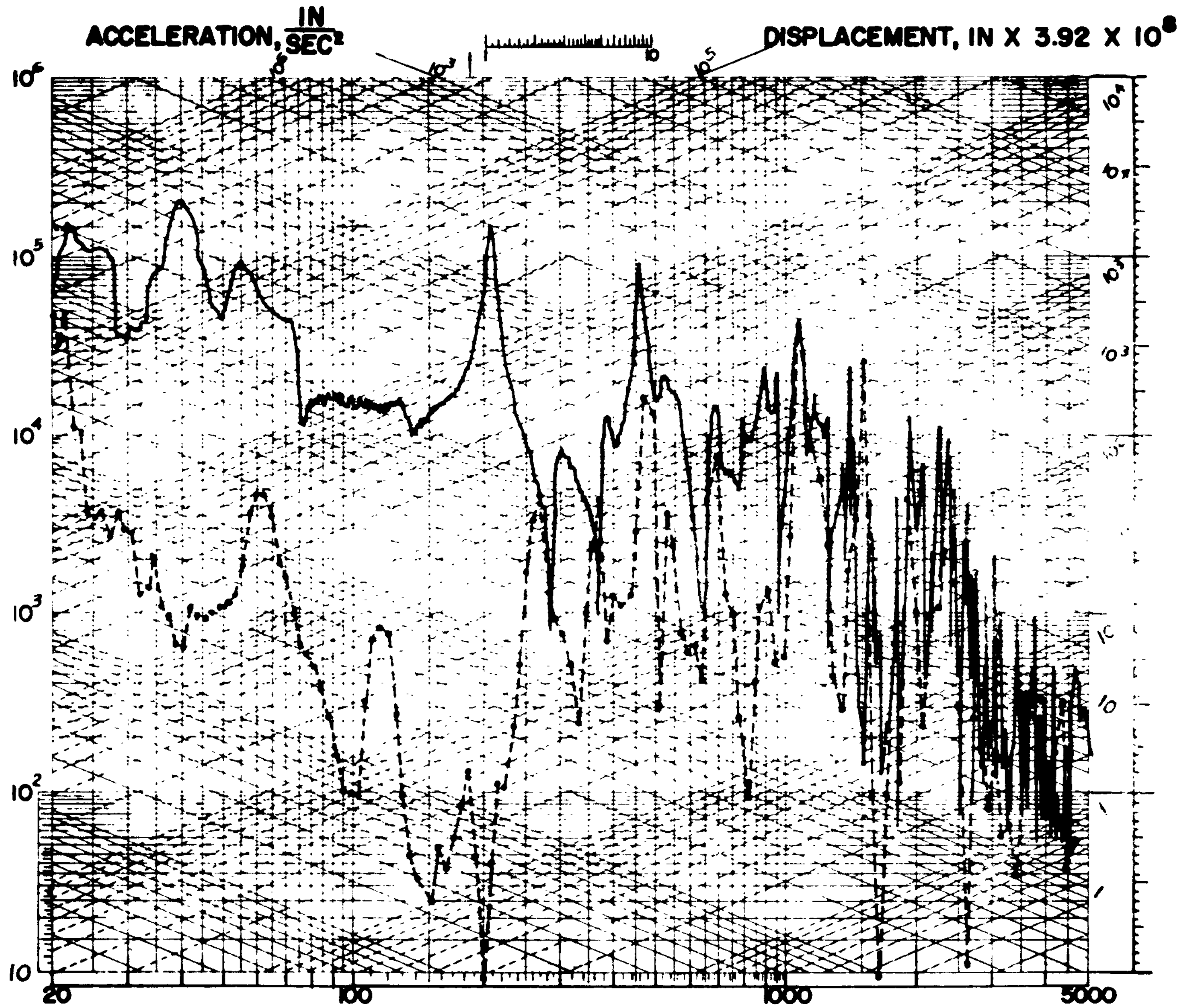
11-39



ACCELERATION, $\frac{IN}{SEC^2}$
DISPLACEMENT, IN X 3.92 X 10^8
VELOCITY, $\frac{IN}{SEC}$ X 10^6
FREQUENCY, CPS
20
100
1000
5000

$V_{5(3)}$

15



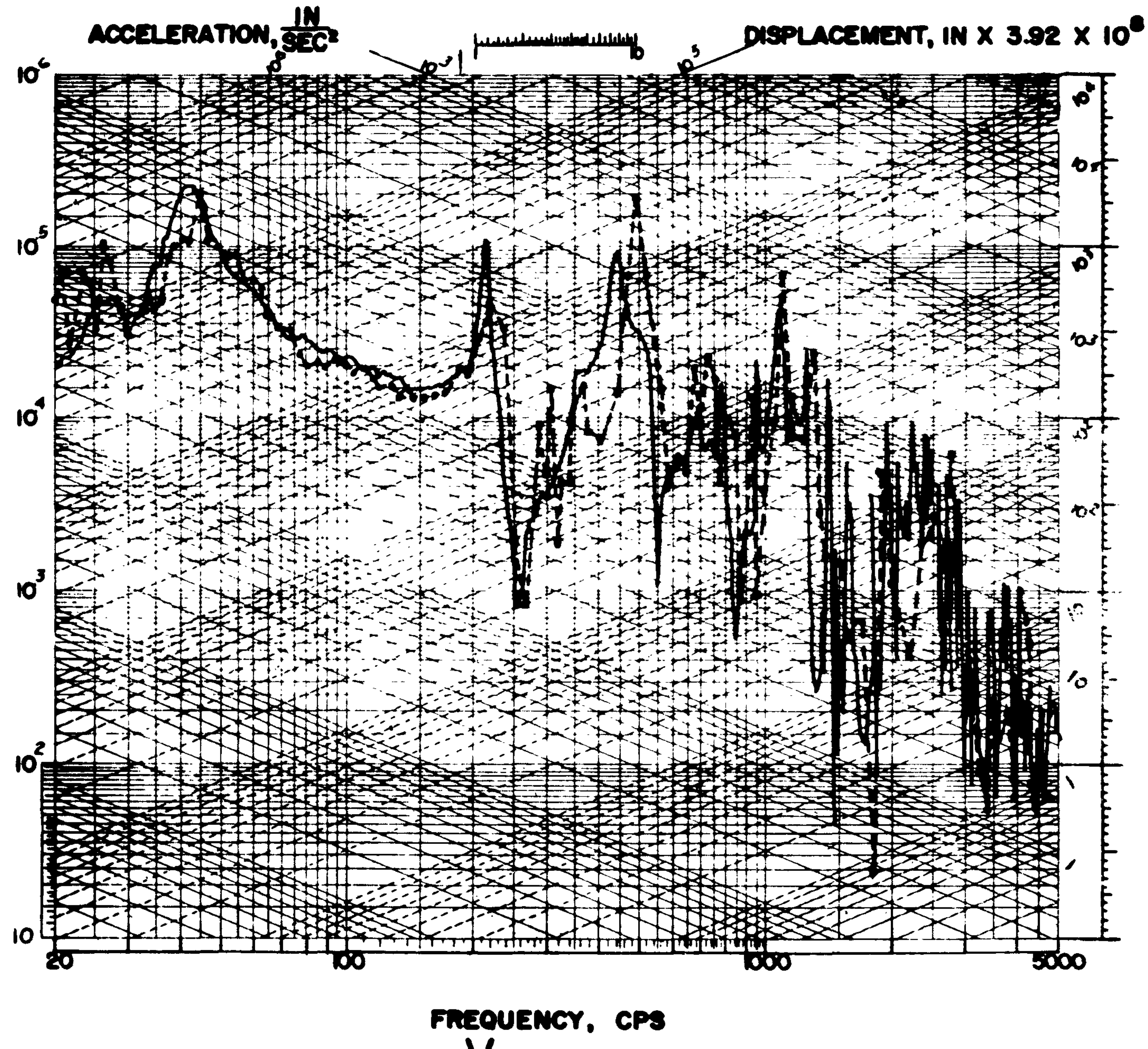
$V_{6(3)}$

PNS TEST T819,029

4

(X 10)

9-40



V_3

DECIBELS

PNS TEST

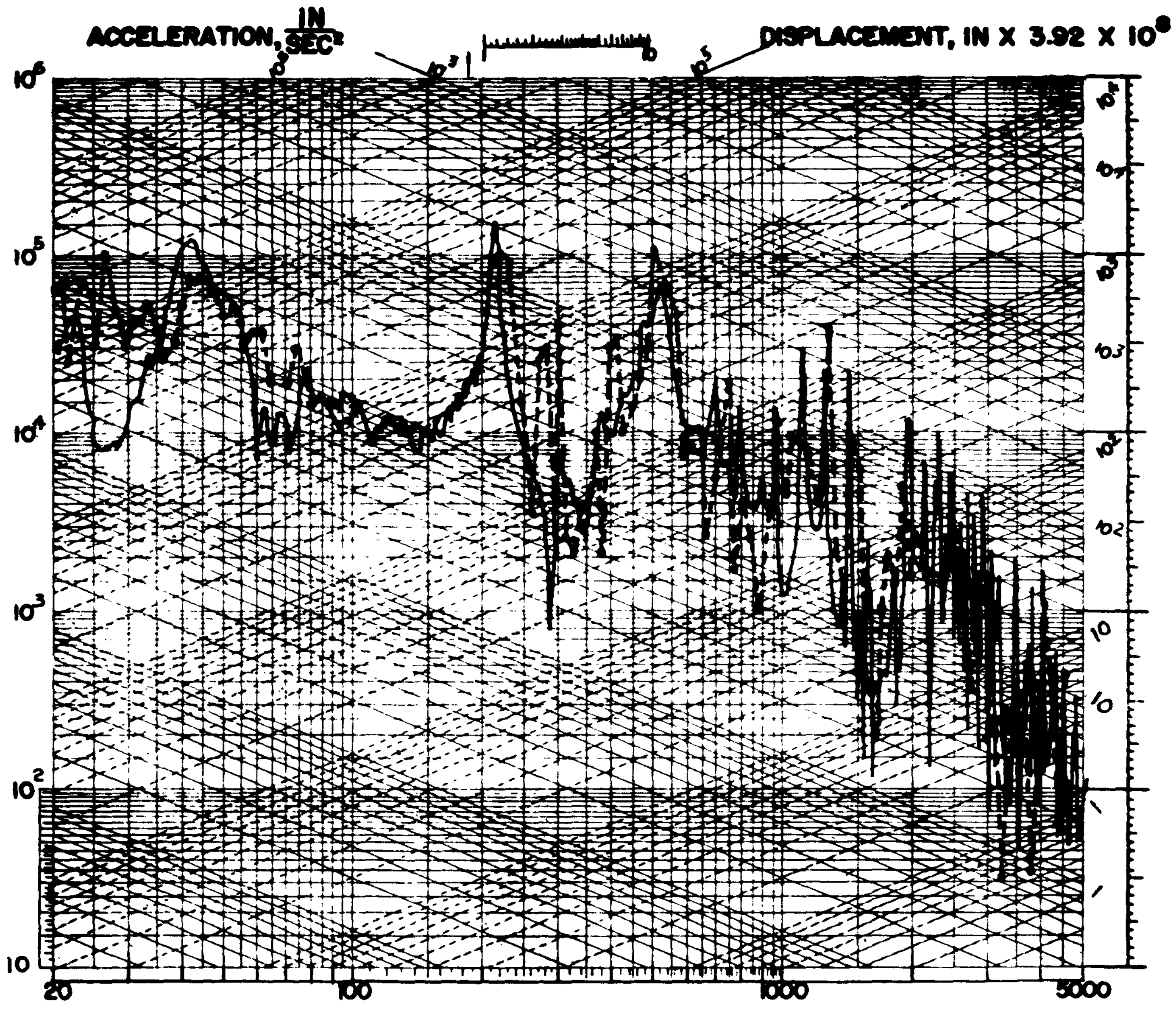
IND - PNS - 1749 (NEW 5-62)

8

(X10)

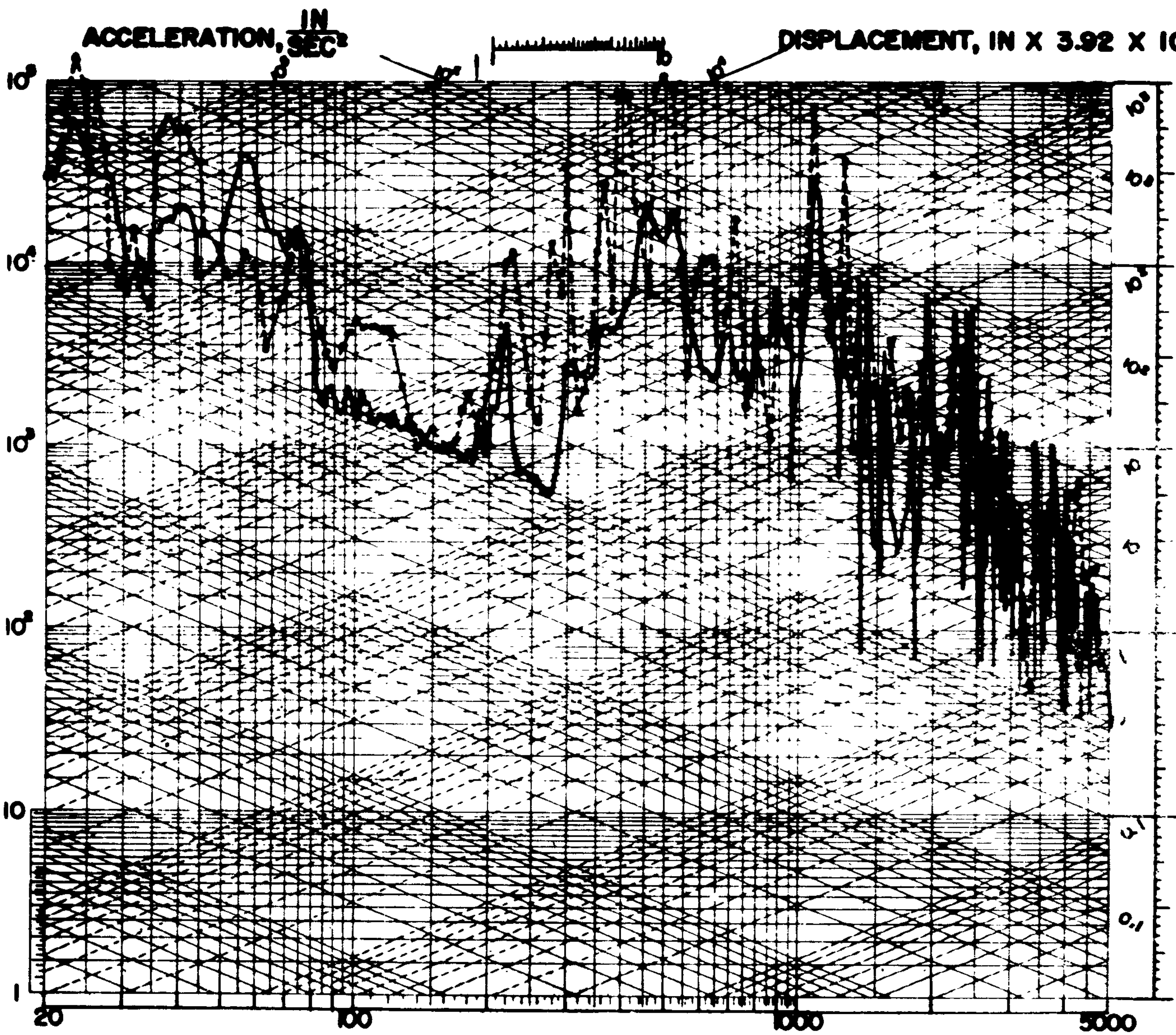
10-4

PNS TEST T819 029



V_4

PNS TEST T819 Q29

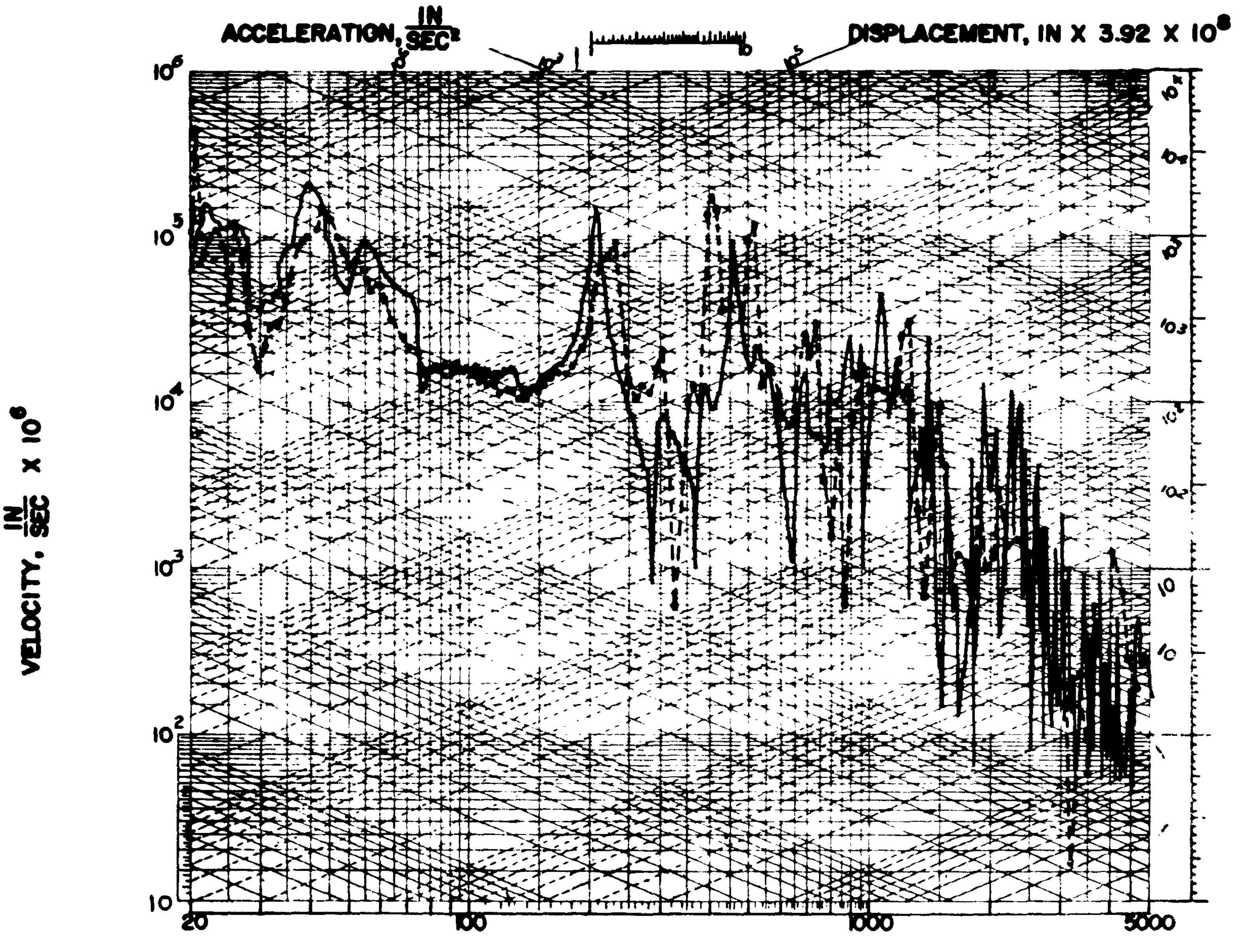


V5

16

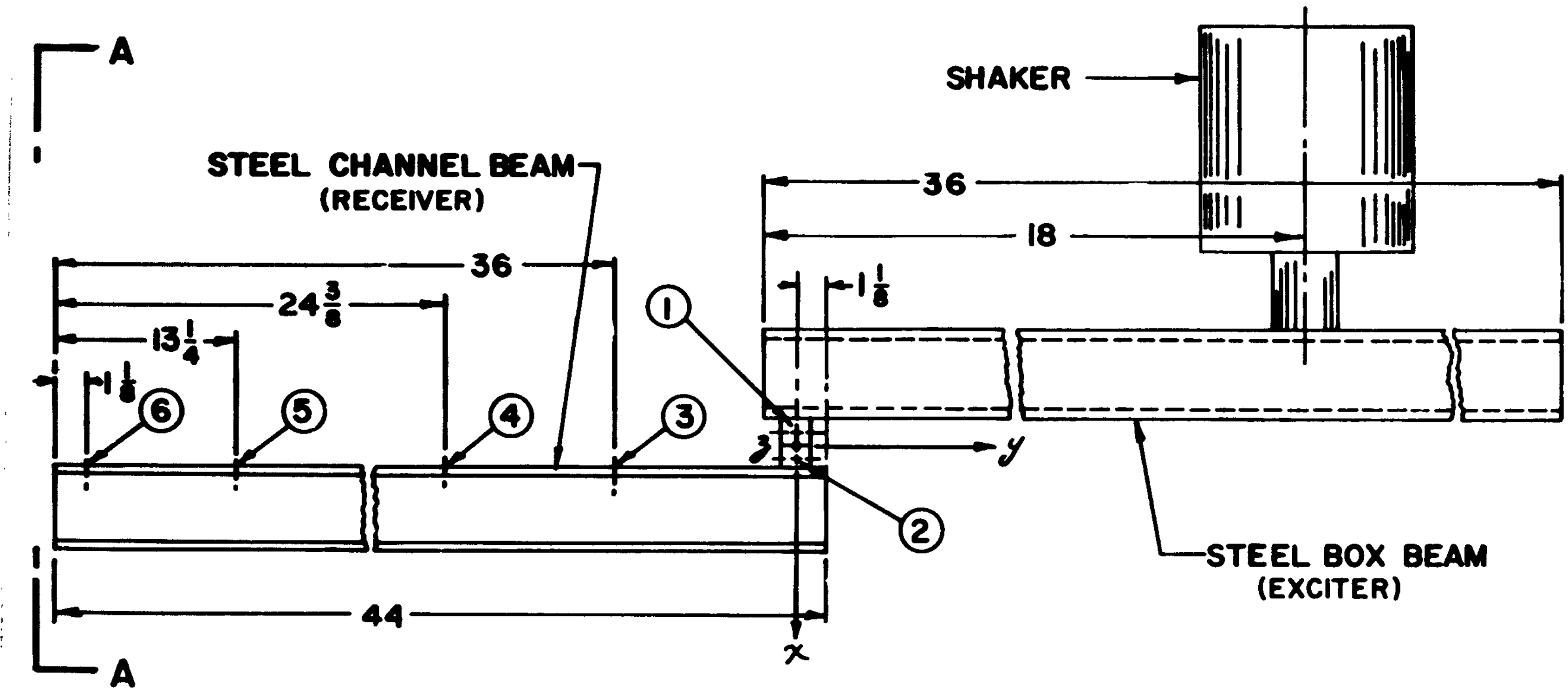
(X10)

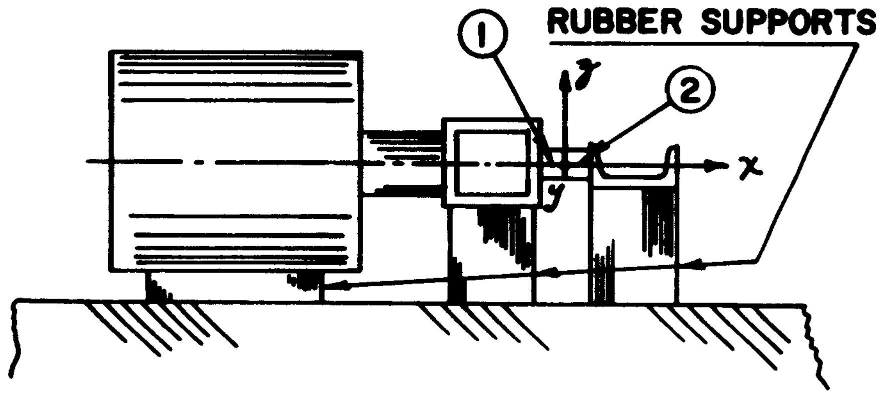
12-40



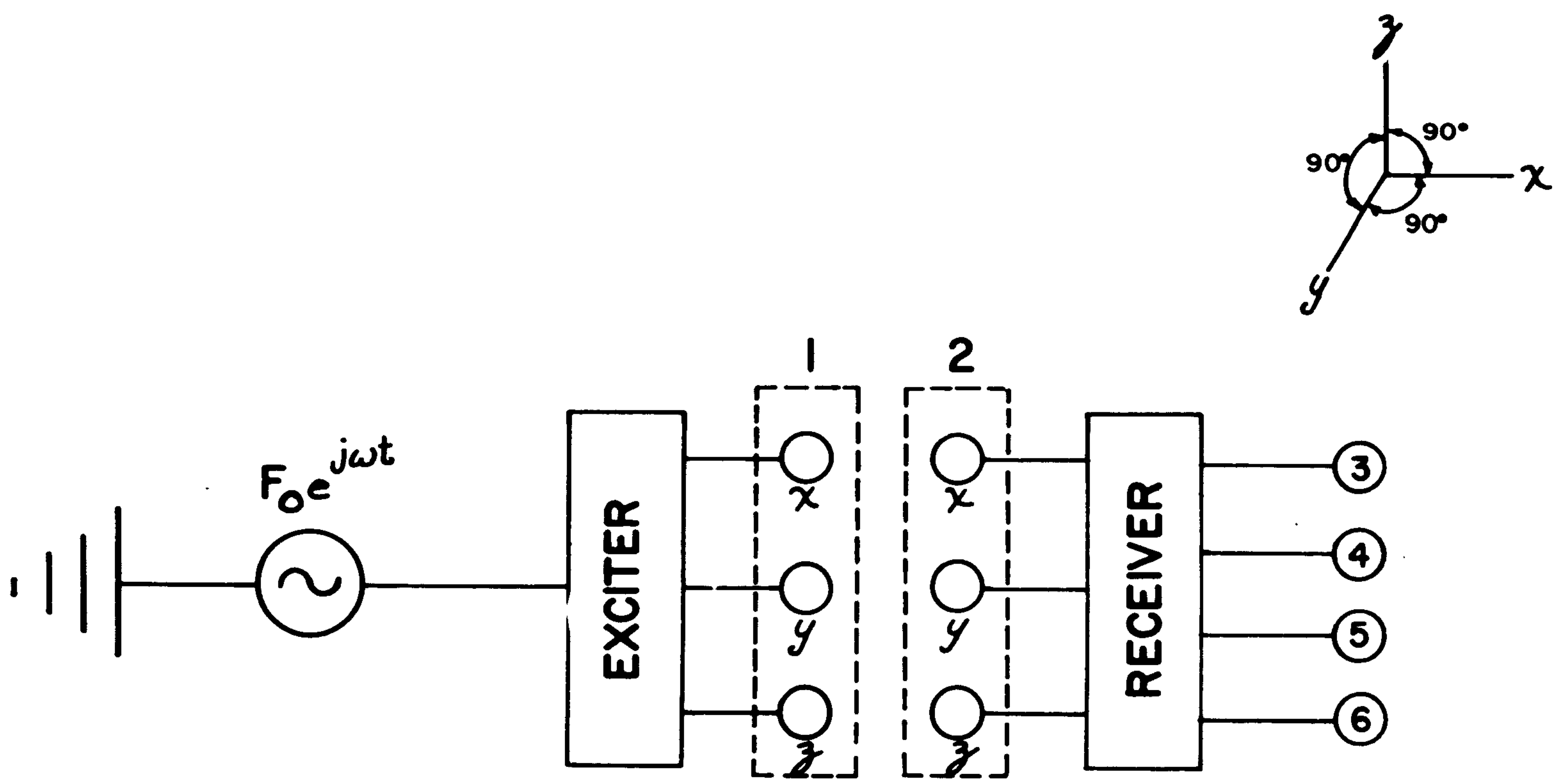
V_6

PNS TEST T819 029





SINGLE CONNECTION
EXCITER-RECEIVER SYSTEM



SCHEMATIC DIAGRAM FOR SINGLE CONNECTION,
THREE DEGREE OF FREEDOM, EXCITER-RECEIVER SYSTEM

—MECHANICAL IMPEDANCE AND PHASE ANGLE INDEX—

SINGLE CONNECTION, THREE DEGREE OF FREEDOM SYSTEM

IMPEDANCE	PAGE		IMPEDANCE	PAGE		IMPEDANCE	PAGE	
	Z	L∅		Z	L∅		Z	L∅
Z_{1x-1x}	26	27	Z_{2y-3}	42	43	Z_{2z-5}	58	59
Z_{2x-2x}	28	29	Z_{2y-4}	44	45	Z_{2z-6}	60	61
Z_{2x-3}	30	31	Z_{2y-5}	46	47	Z_{1x-1y}	62	63
Z_{2x-4}	32	33	Z_{2y-6}	48	49	Z_{1x-1z}	64	65
Z_{2x-5}	34	35	Z_{1z-1z}	50	51	Z_{1y-1z}	66	67
Z_{2x-6}	36	37	Z_{2z-2z}	52	53	Z_{2x-2y}	68	69
Z_{1y-1y}	38	39	Z_{2z-3}	54	55	Z_{2x-2z}	70	71
Z_{2y-2y}	40	41	Z_{2z-4}	56	57	Z_{2y-2z}	72	73

NOTES:

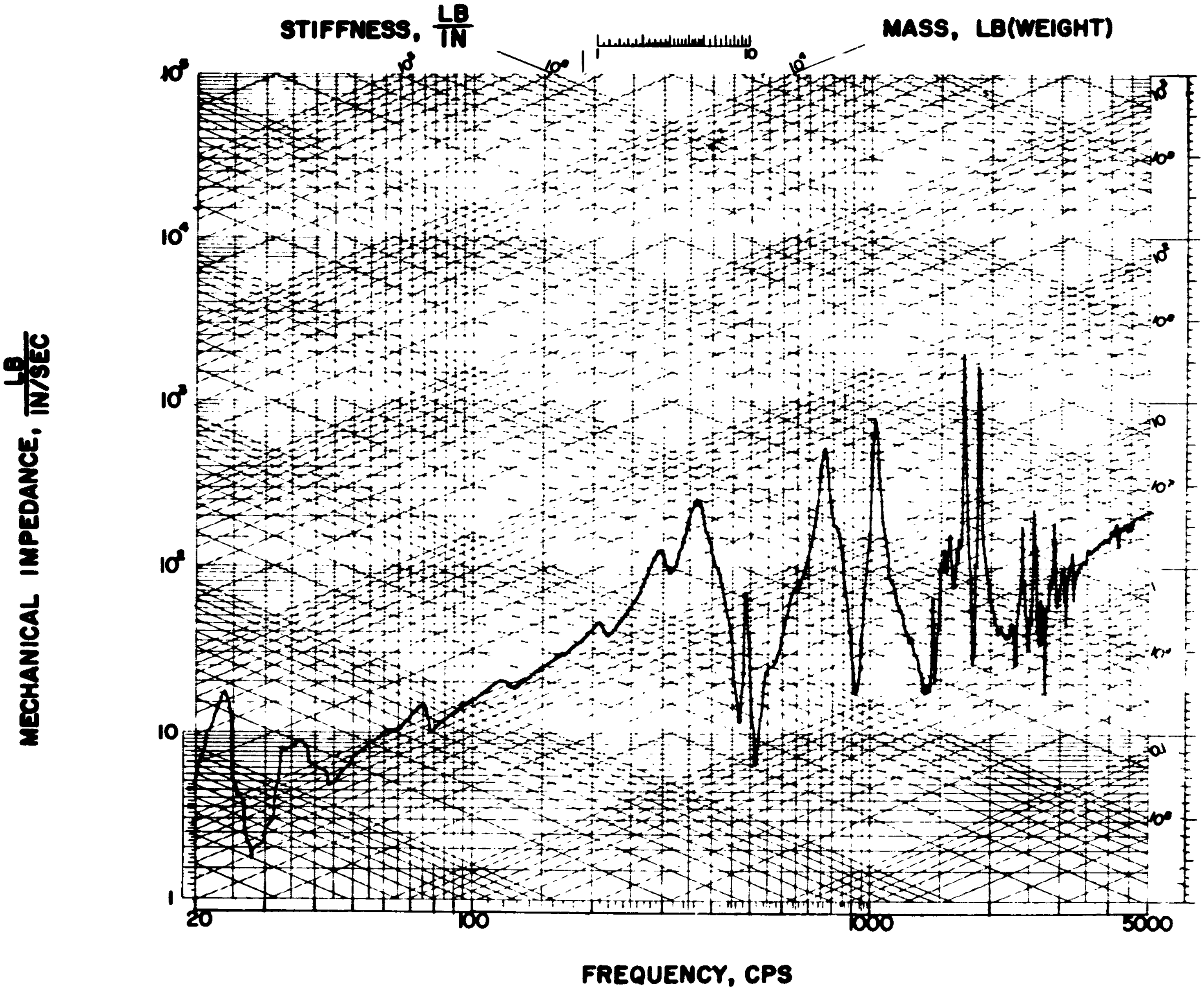
1. NOTATION $Z_{N_1-N_2}$ SIGNIFIES FORCE MEASURED AT (N_1) AND RESPONCE MEASURED AT (N_2).
2. NOTATION V_{01n} INDICATES THE FREE VELOCITY OF EXCITER TERMINAL 1 ALONG THE AXIS n.

—FREE VELOCITY AND PHASE ANGLE INDEX—

VELOCITY	PAGE		VELOCITY	PAGE		VELOCITY	PAGE	
	V	L∅		V	L∅		V	L∅
V_{01x}	74	REF.	V_{01y}	75	76	V_{01z}	77	78

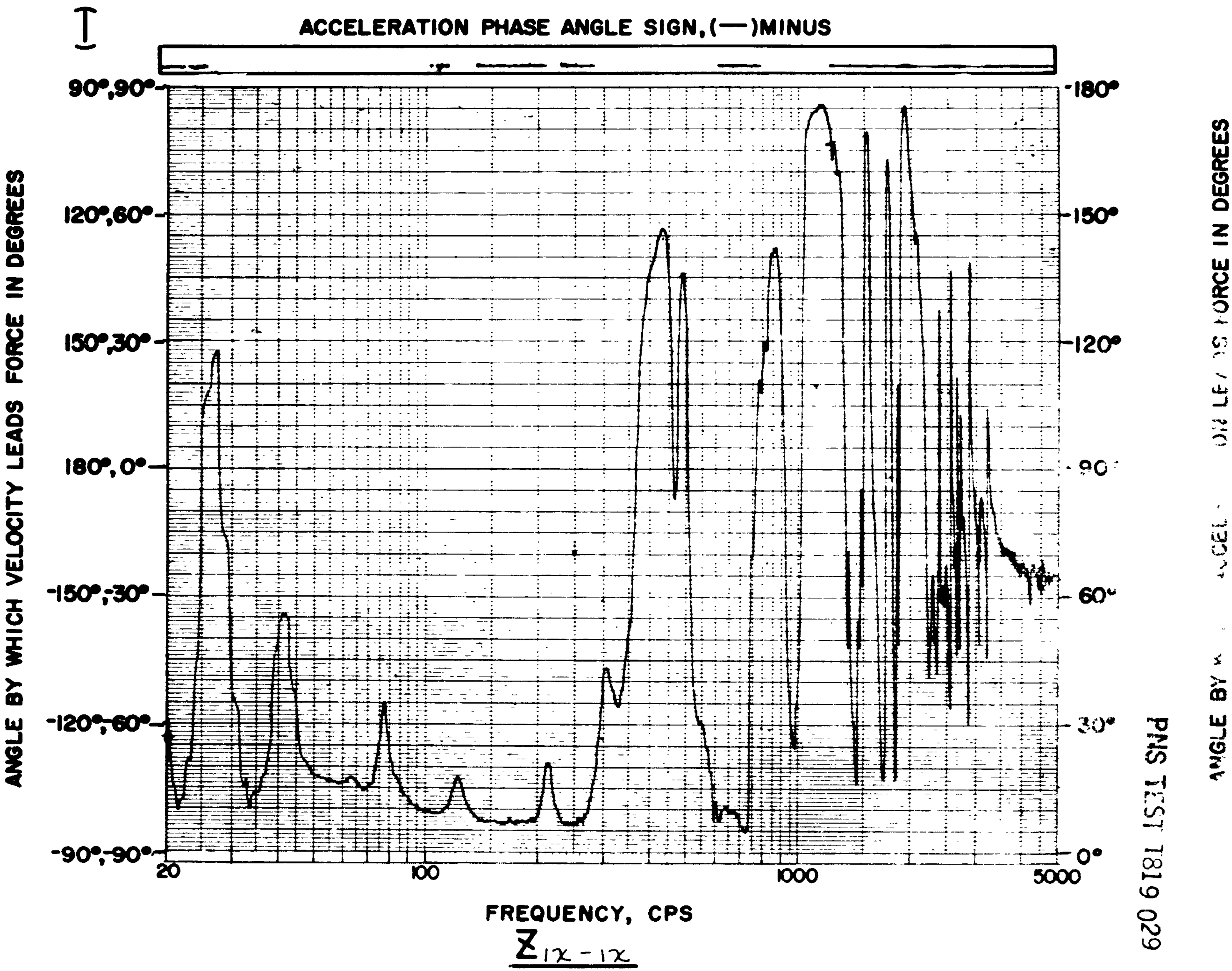
#1

PNS TEST T819 029



Z_{1X-1X}

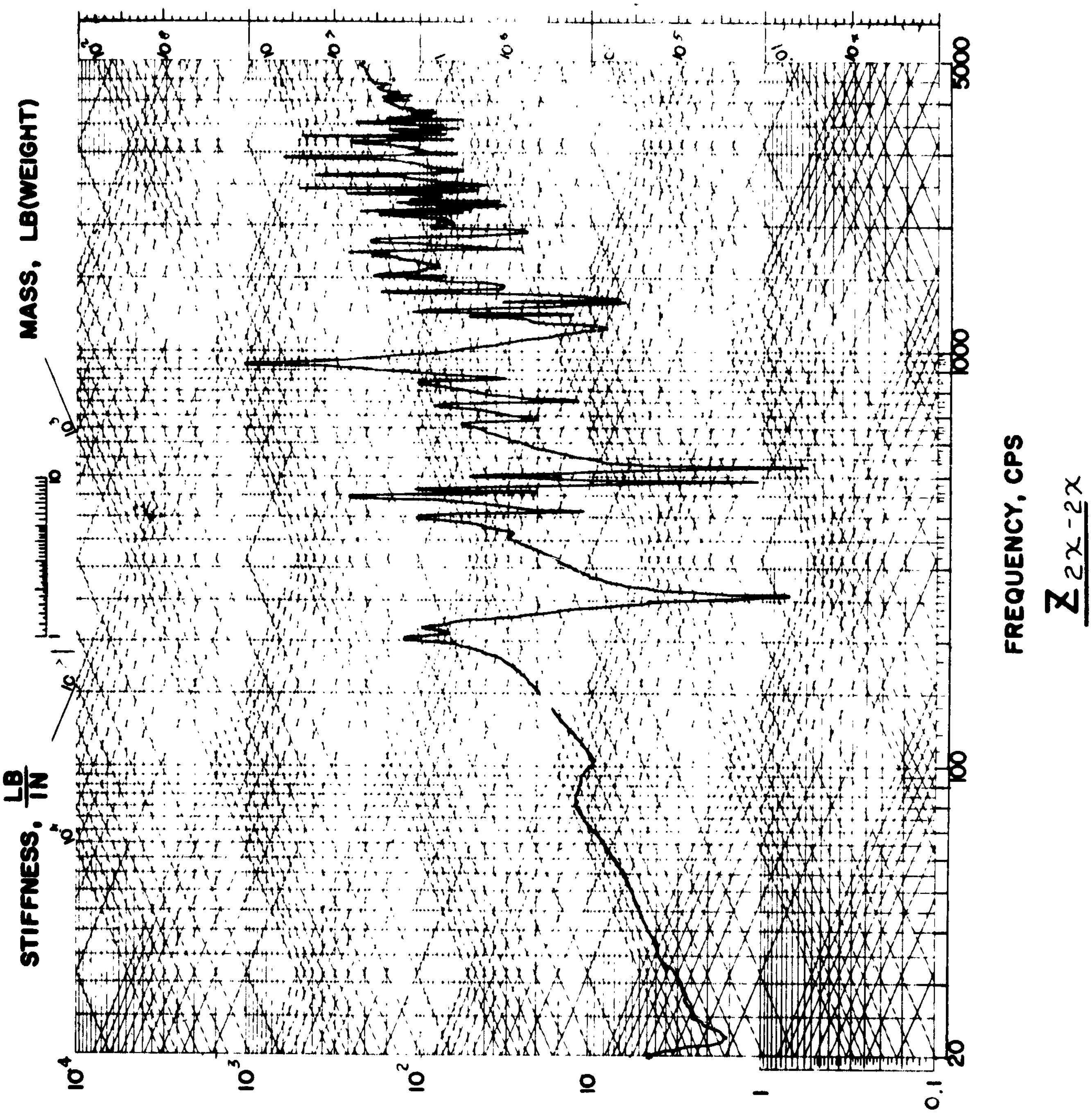
IND-PNS-1750 (NEW 5-62)



PNS TEST T819 029

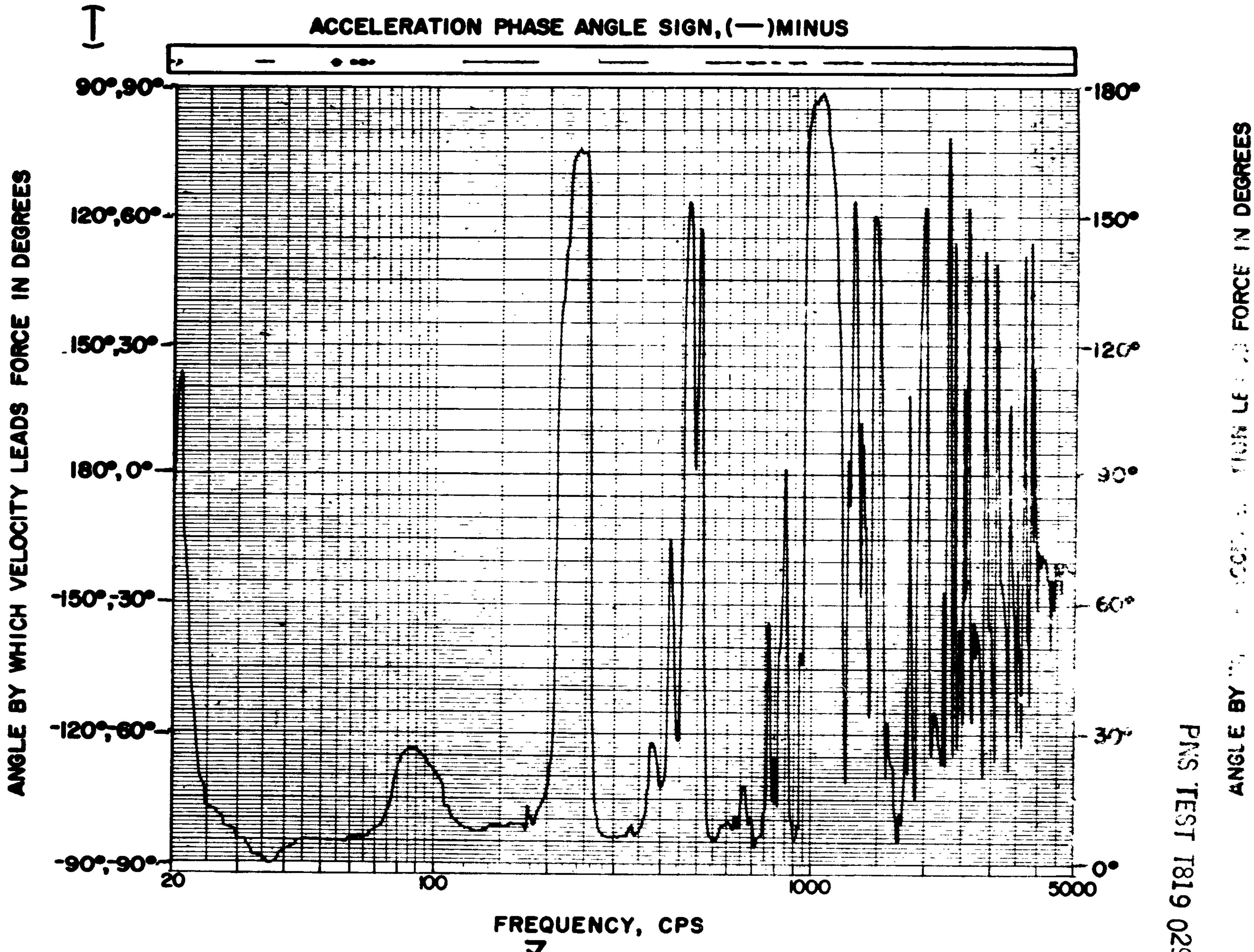
5 ($X10^{-1}$)

PNS TEST T819 029



MECHANICAL IMPEDANCE, $\frac{LB}{IN/SEC}$

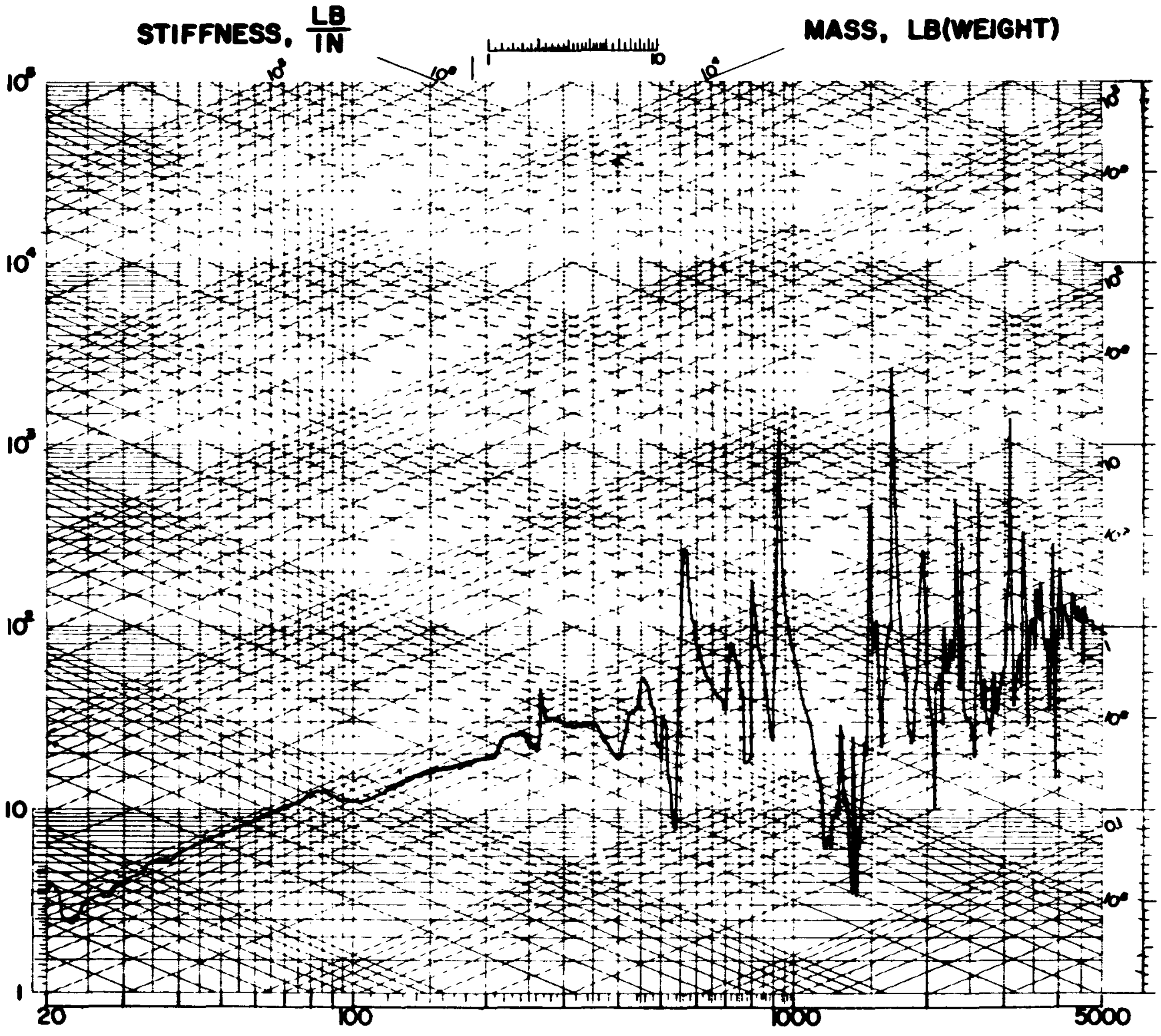
IND-PNS-1750 (NEW 5-62)



$\underline{Z_{2x-2x}}$

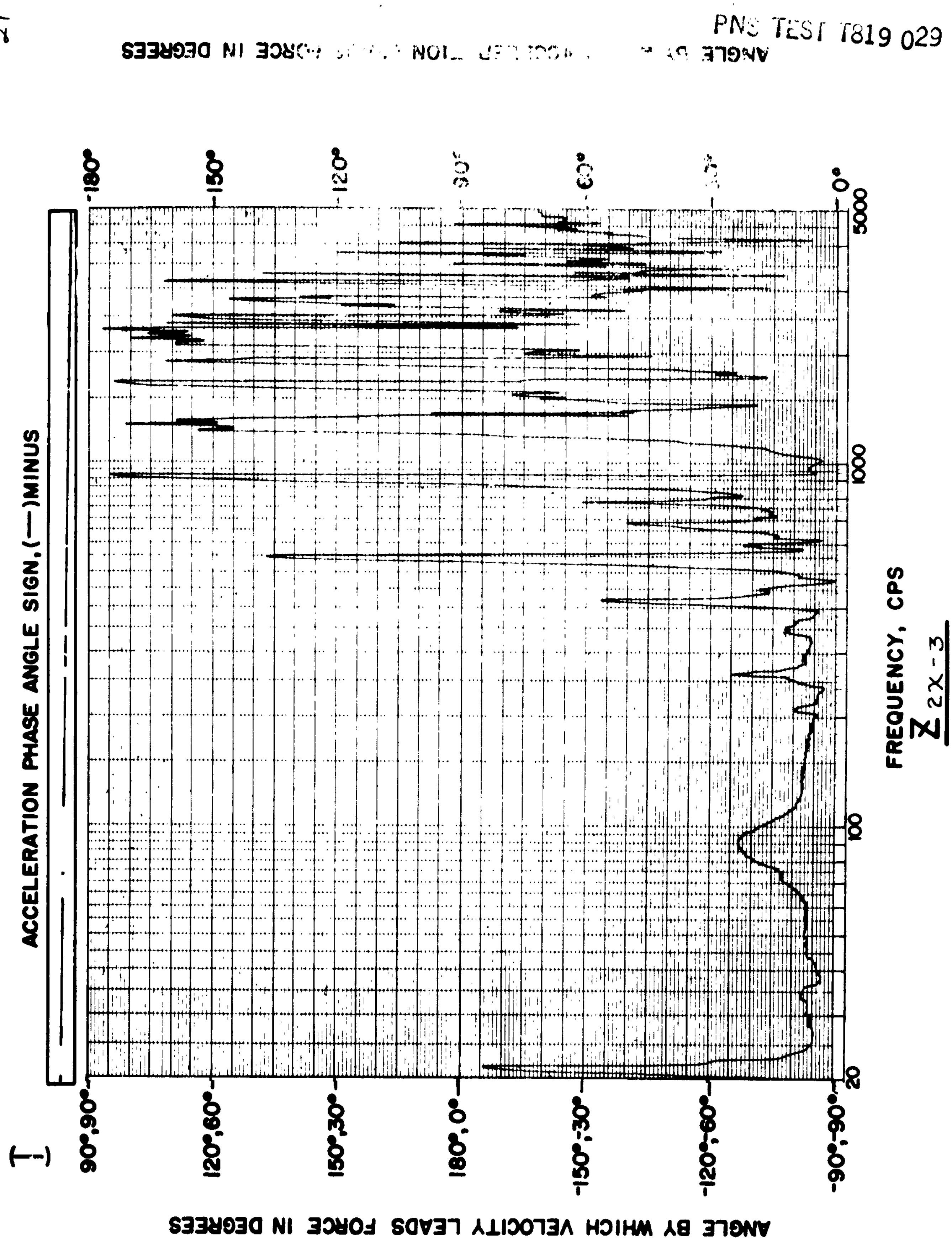
PNS TEST T819 029

IND-PNS-1751 (NEW 5-62)



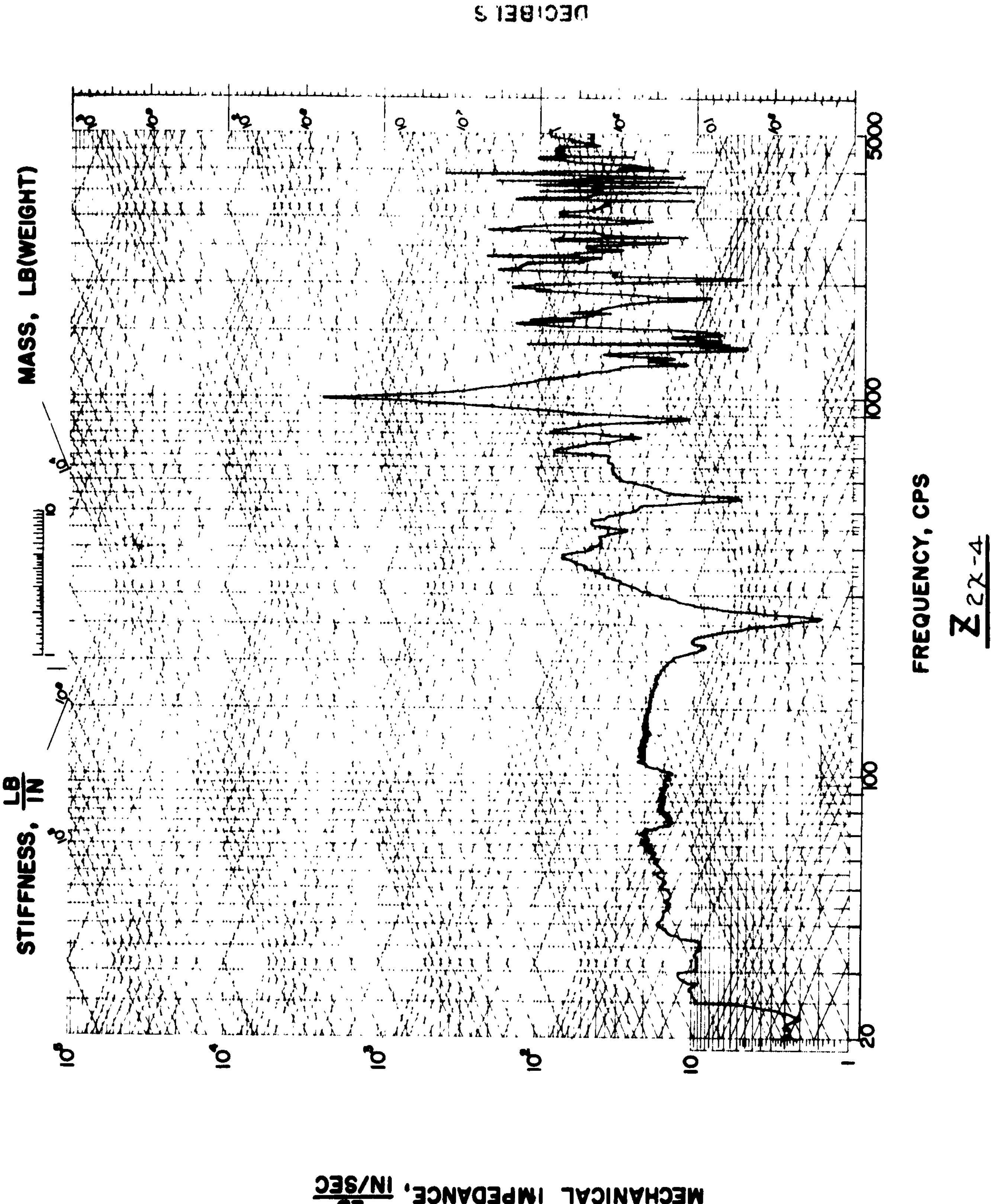
Z_{2X-3}

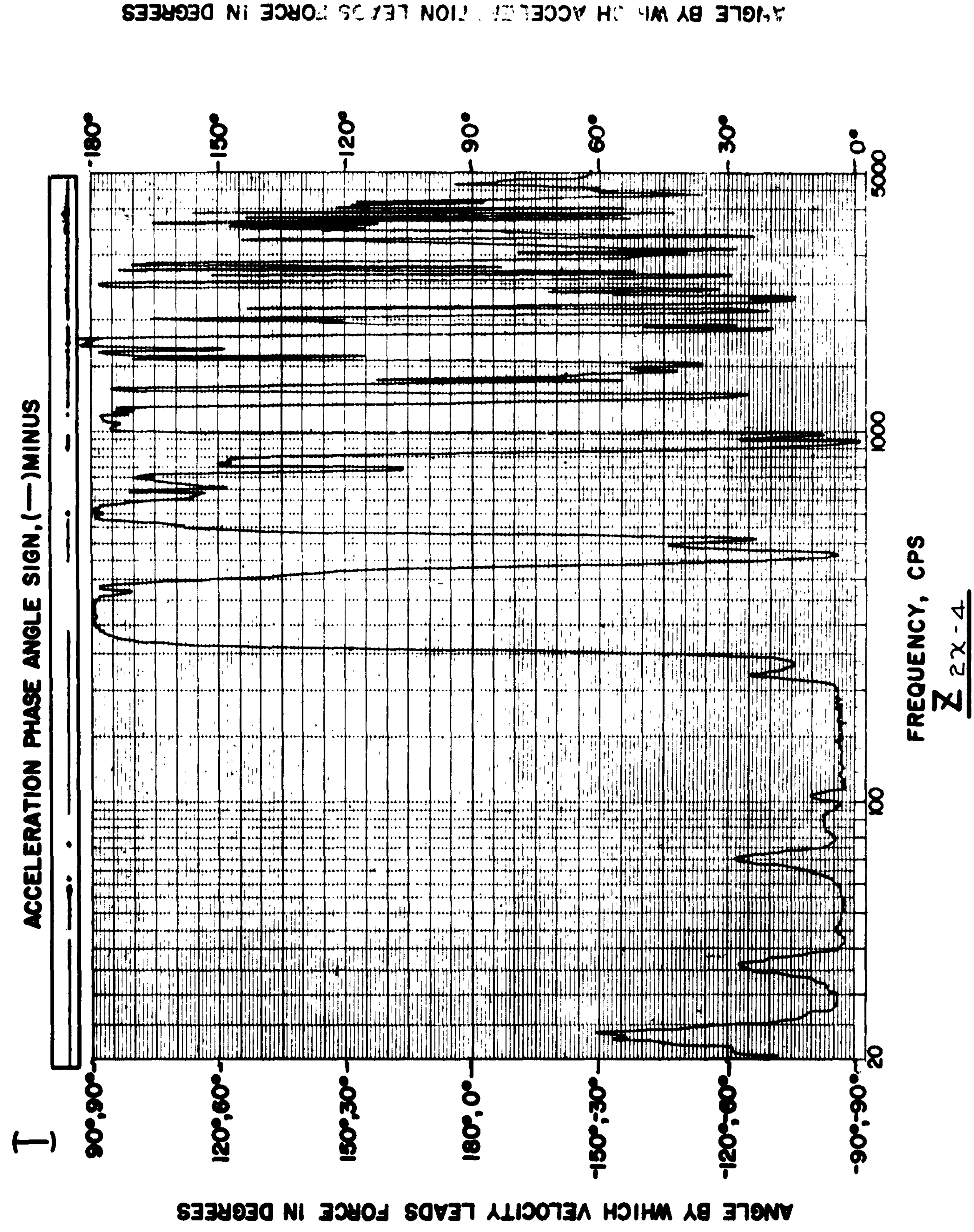
PNS TEST T819 029



IND-PNS-1751 (NEW 5-62)

35

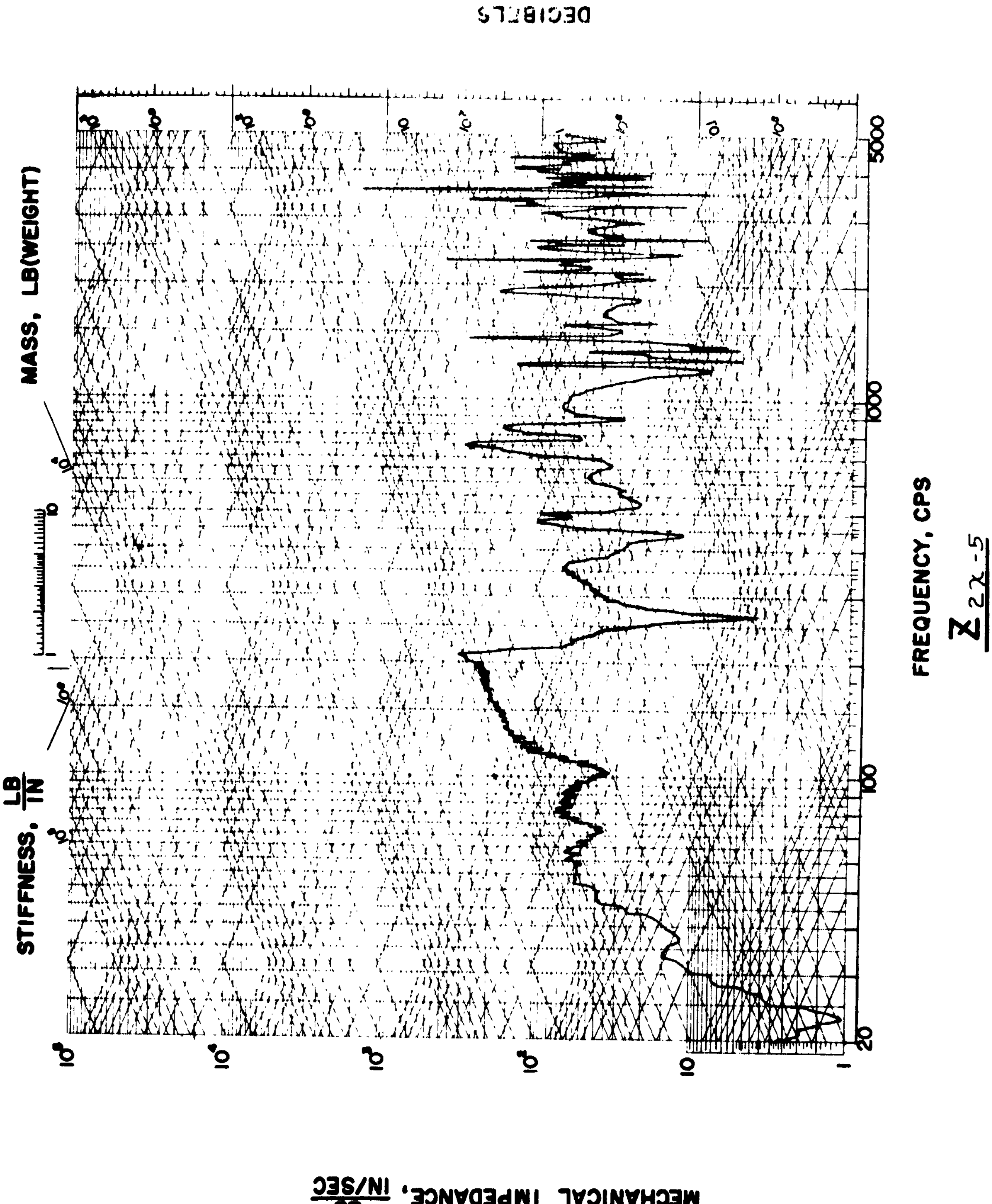

DECIBELS
STIFFNESS, LB/IN
MASS, LB(WEIGHT)
FREQUENCY, CPS
Z_{2X-4}
MECHANICAL IMPEDANCE, LB / IN/SEC
20
100
1000
5000
1
10



IND-PNS-1751 (NEW 5-62)

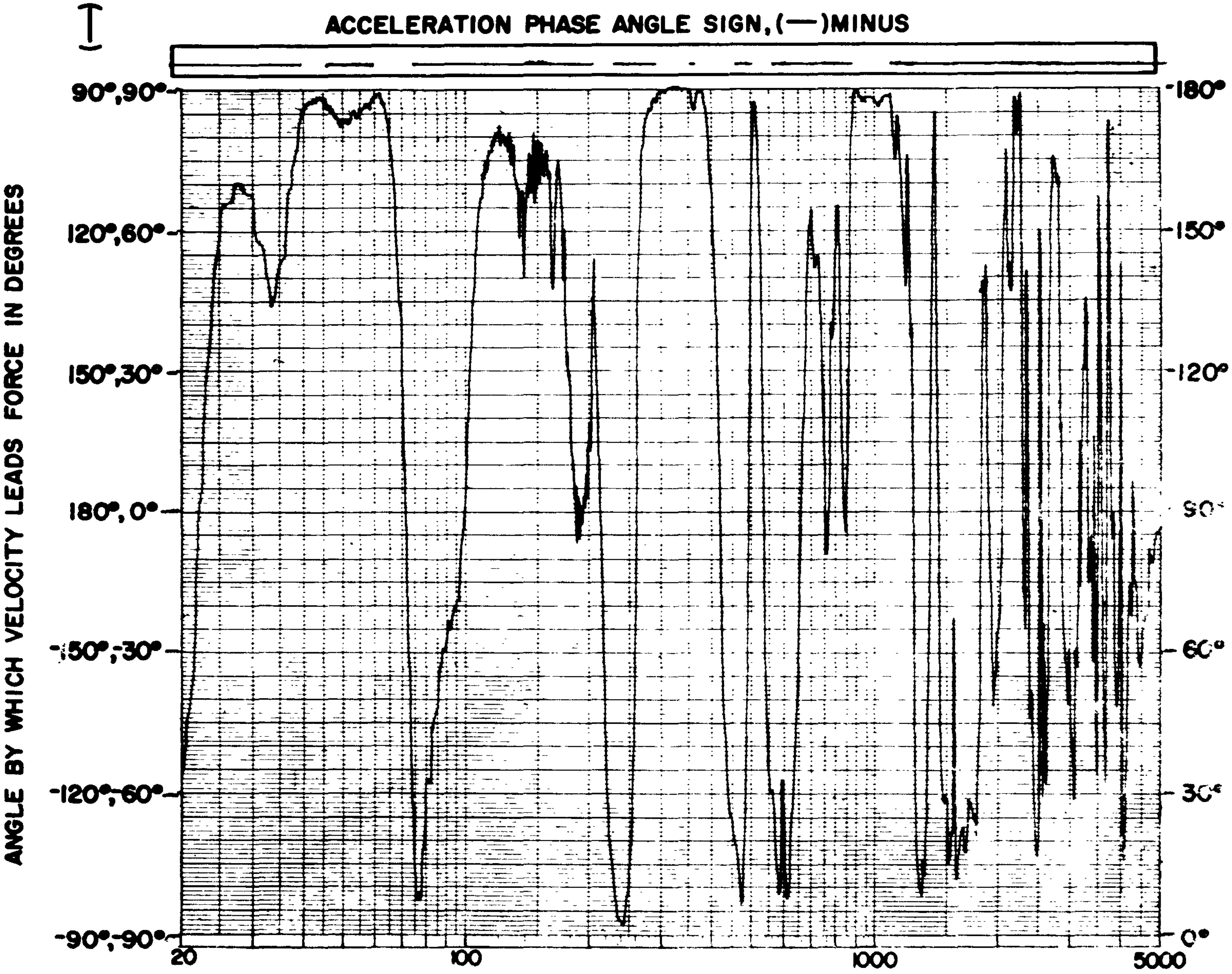
29

PNS TEST T819 029



IND-PNS-1750 (NEW 5-62)

29

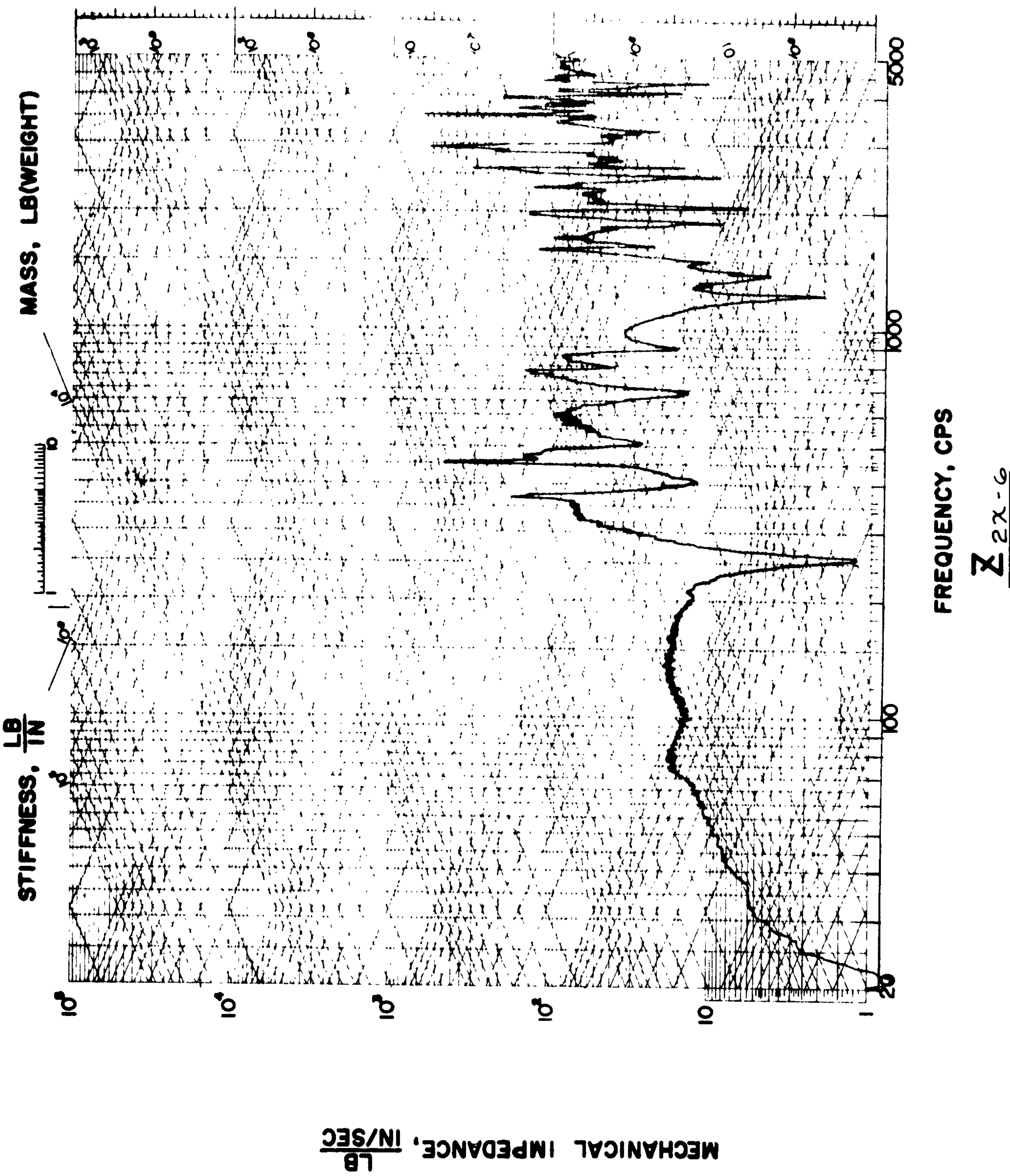


Z_{2X-5}

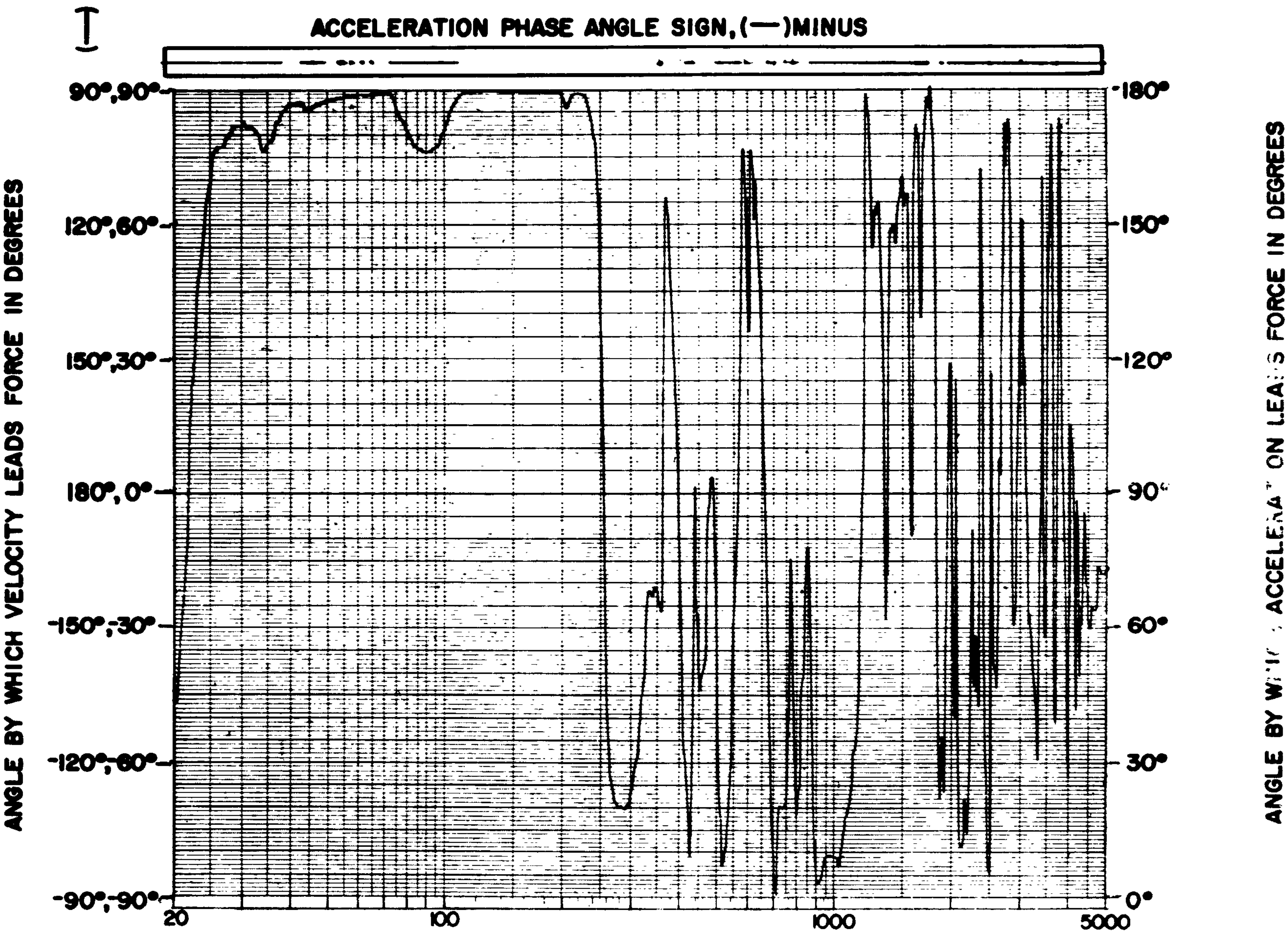
TEST T819 029

IND-PNS-1751 (NEW 5-62)

33


STIFFNESS, LB/IN
MASS, LB(WEIGHT)
FREQUENCY, CPS
Z 2X-6
MECHANICAL IMPEDANCE, LB/IN/SEC
20
100
1000
5000

33

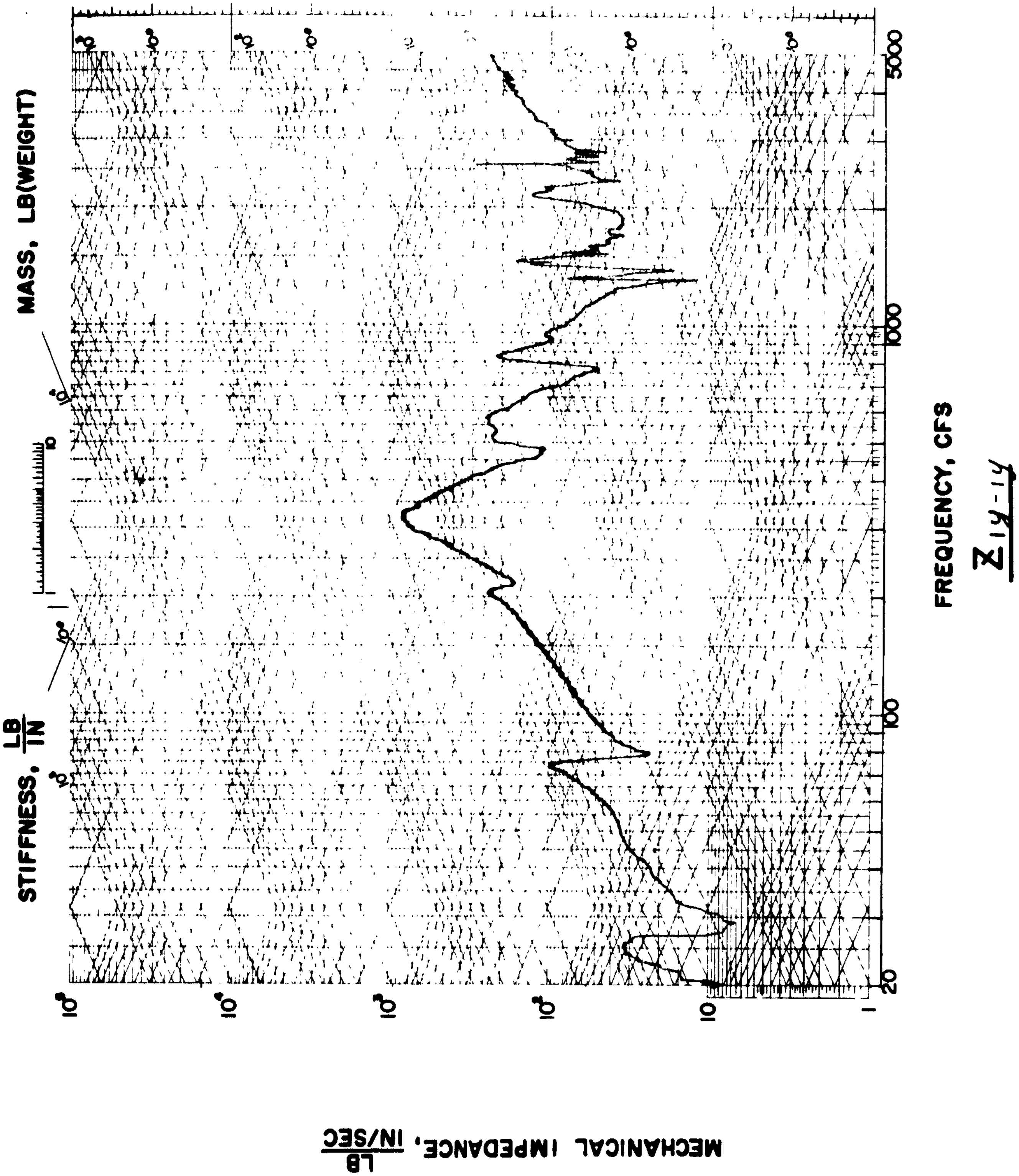


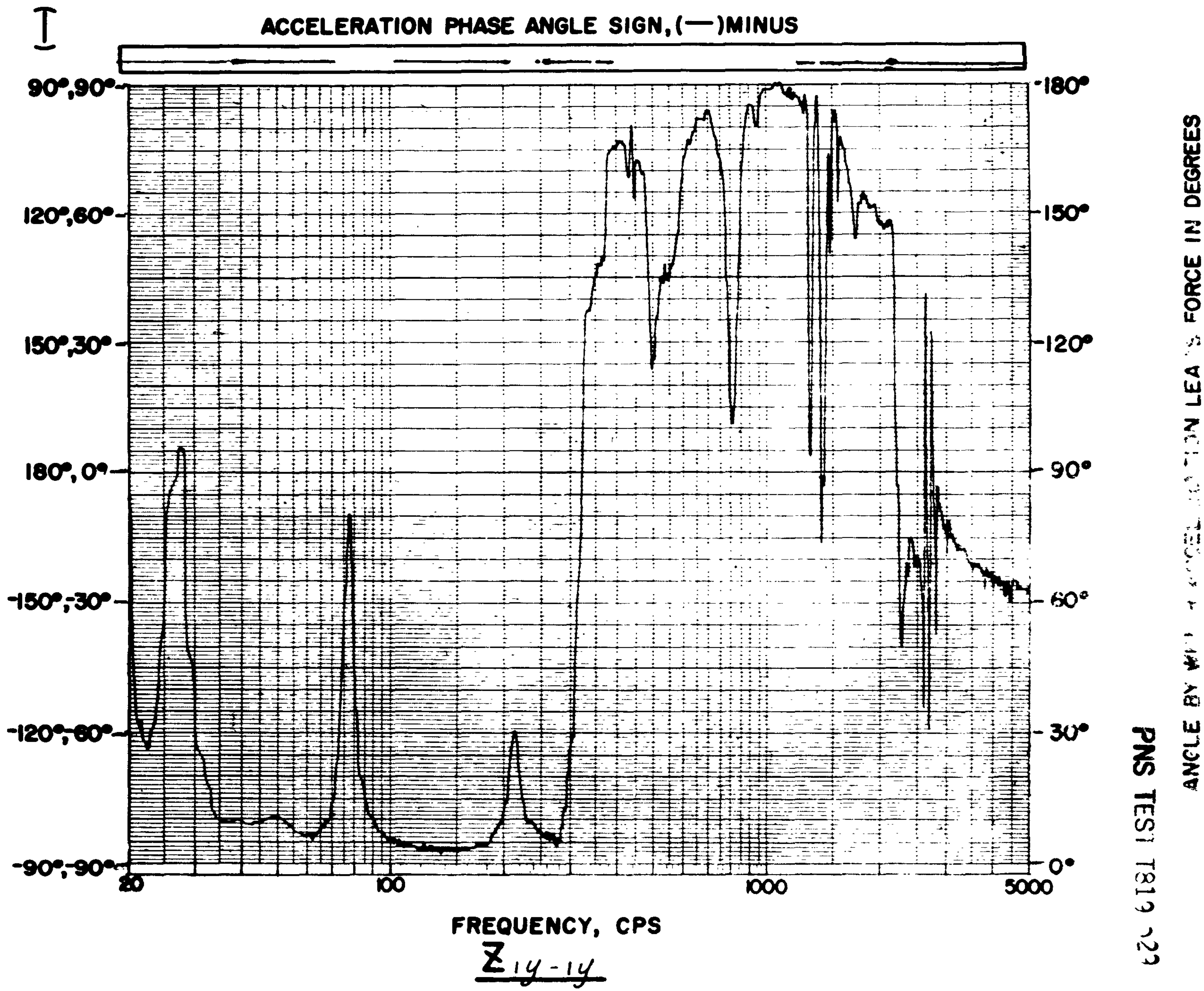
Z_{2X-6}

PNS TEST T819 029

IND-PNS-1751 (NEW 5-62)

9


STIFFNESS, LB/IN
MASS, LB(WEIGHT)
FREQUENCY, CPS
Z14-14
MECHANICAL IMPEDANCE, LB / IN/SEC
20
100
1000
5000
10
1

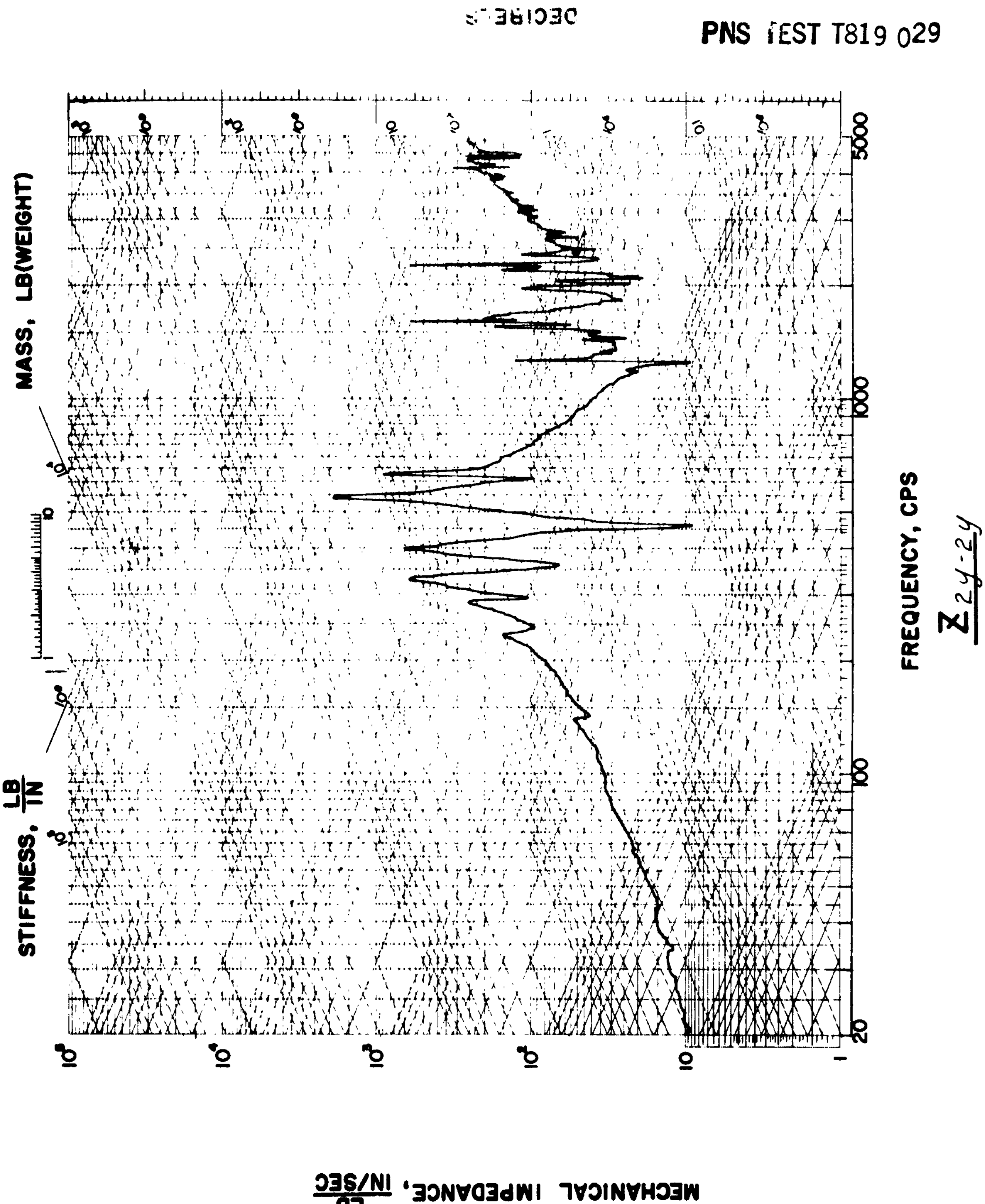


I
ACCELERATION PHASE ANGLE SIGN, (—) MINUS
ANGLE BY WHICH VELOCITY LEADS FORCE IN DEGREES
90°, 90°
120°, 60°
150°, 30°
180°, 0°
-150°, -30°
-120°, -60°
-90°, -90°
180°
150°
120°
90°
60°
30°
0°
20
100
1000
5000
FREQUENCY, CPS
Z14-14
PNS TEST T819 -23

9

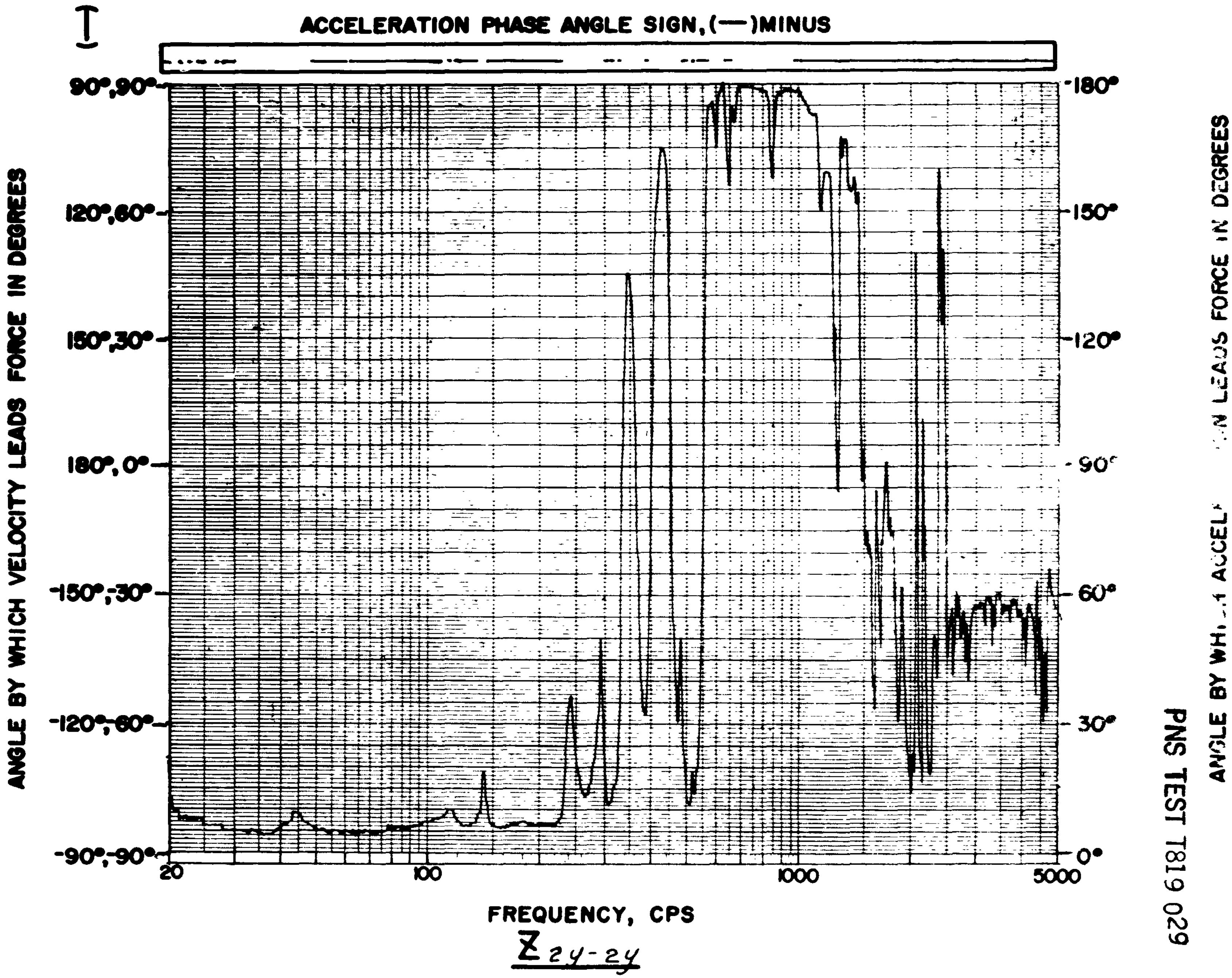
12

PNS TEST T819 029



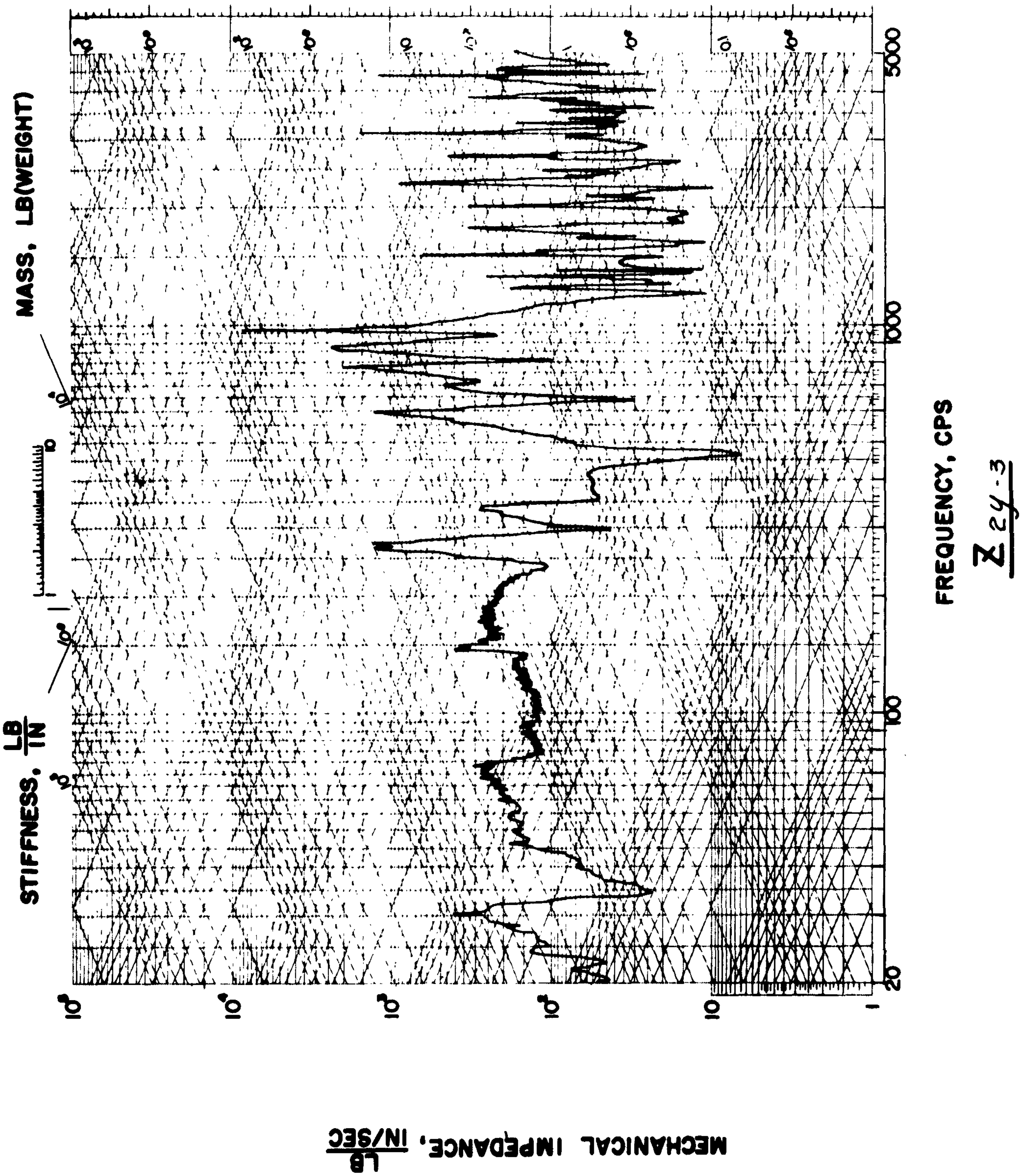
IND-PNS-1750 (NEW 5-62)

PNS TEST T819 029

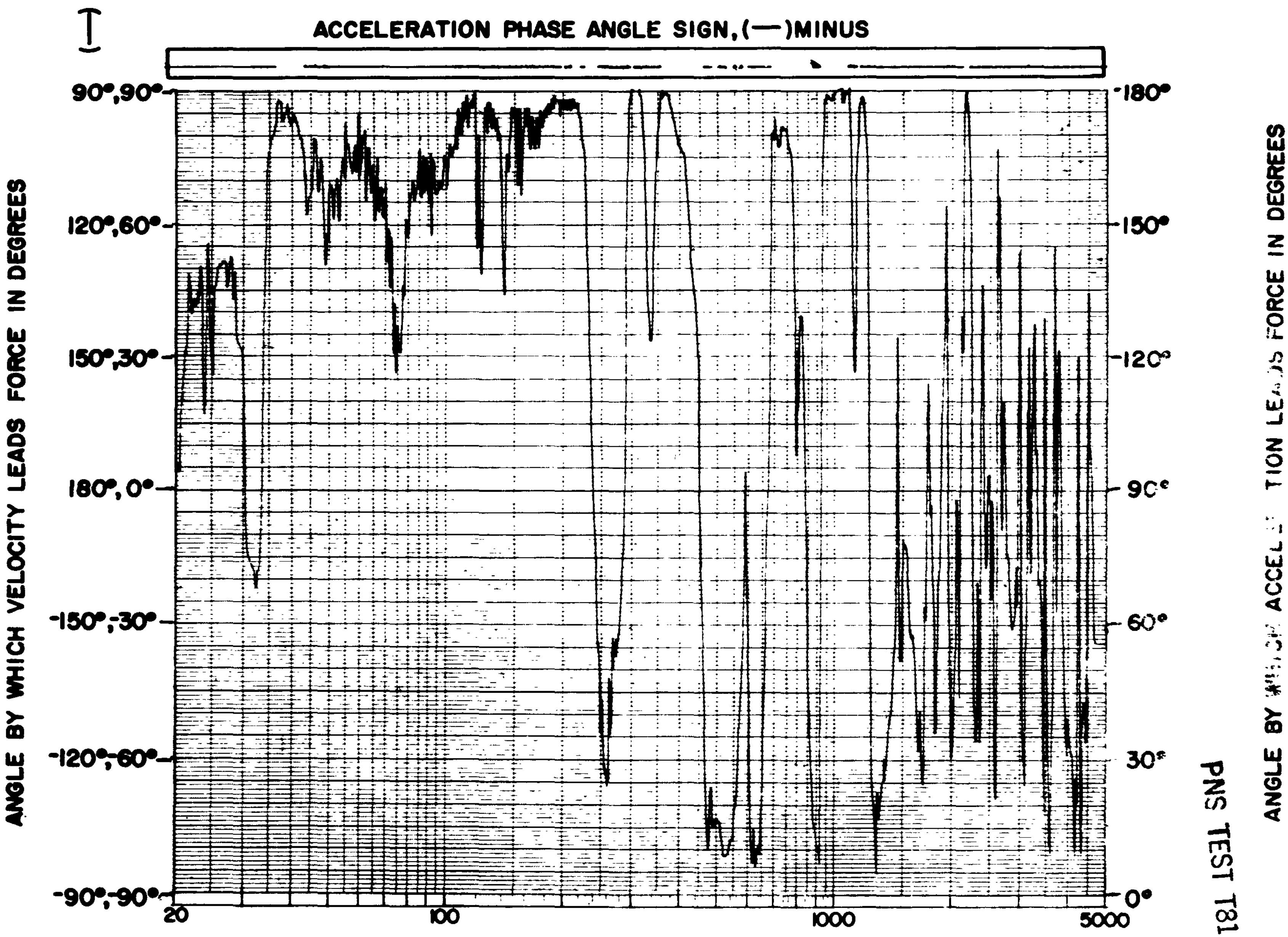


IND-PNS-1751 (NEW 5-62)

PNS TEST T819 029



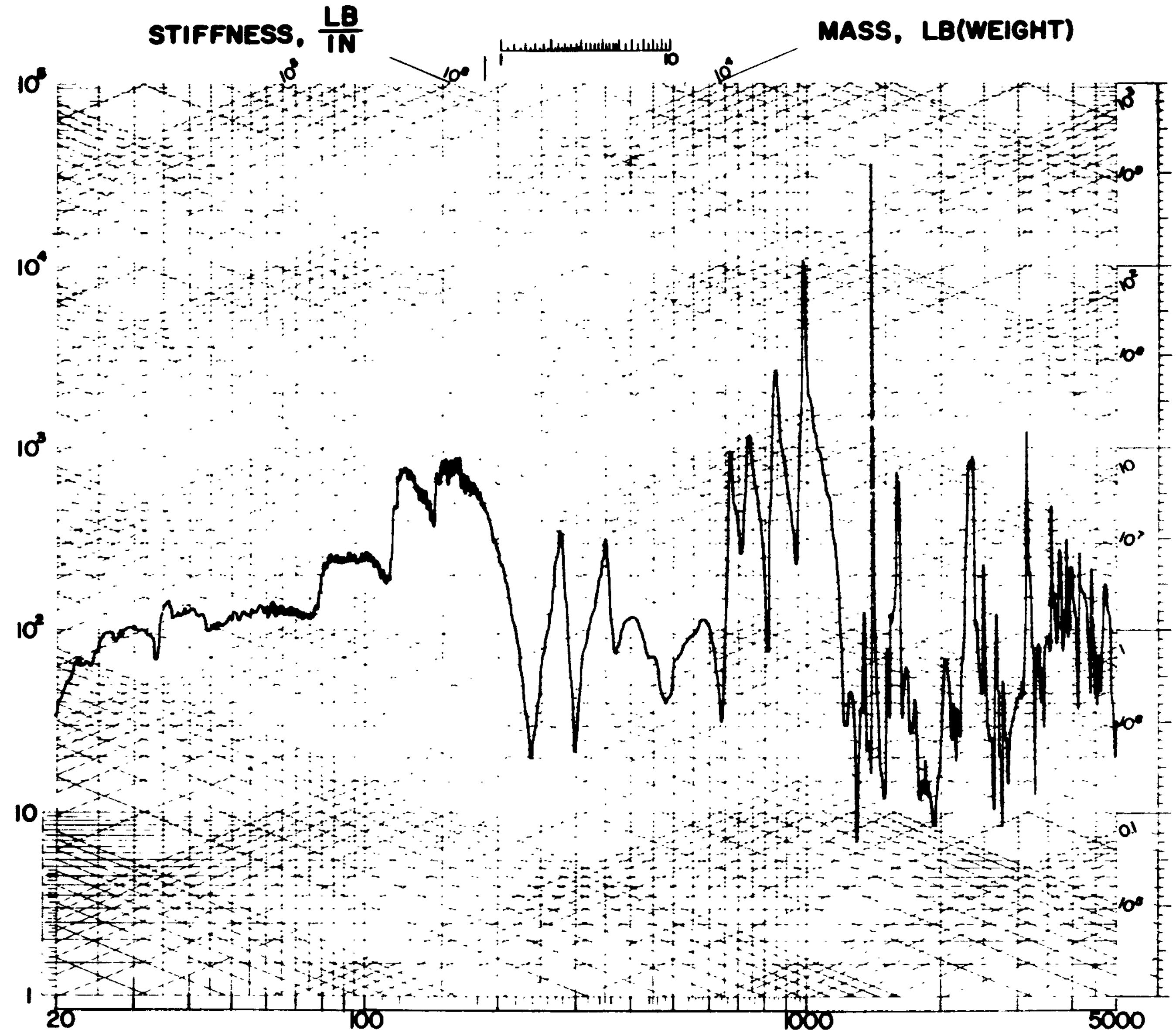
22



Z 2y-3

PNS TEST T819 029

26

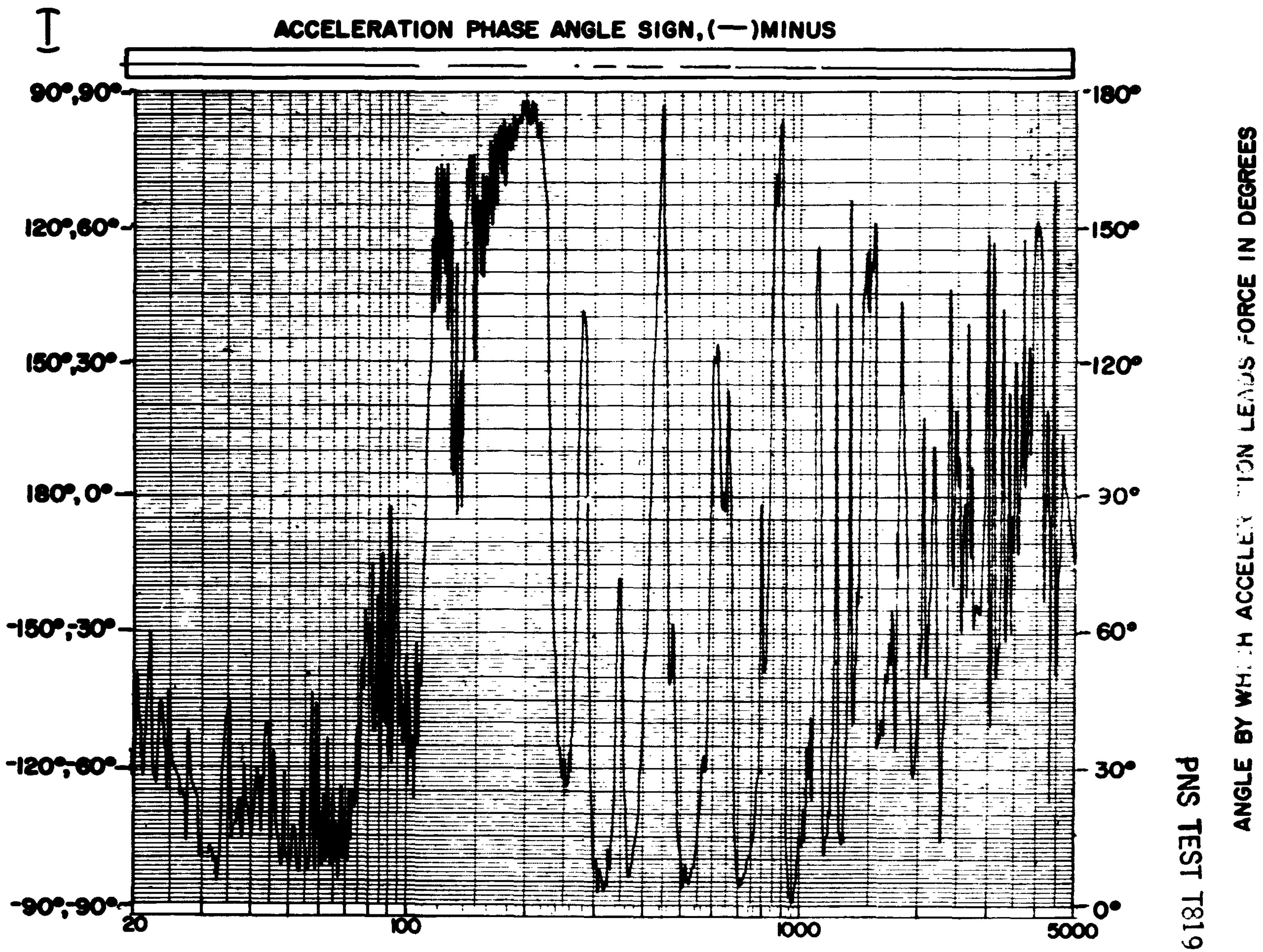


PNS TEST T819 029

Z_{2y-4}

IND-PNS-1750 (NEW 5-62)

26

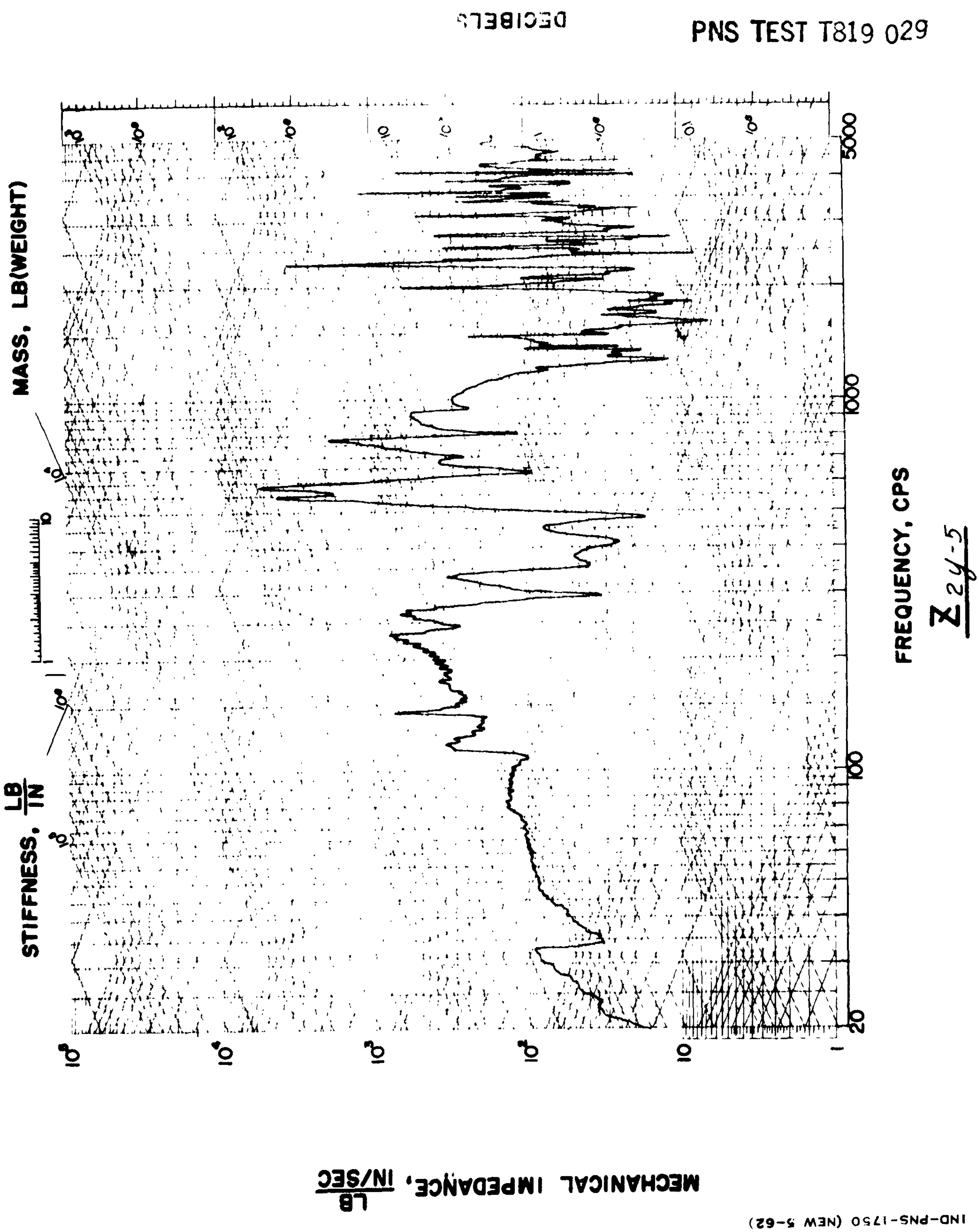


Z_{2y-4}

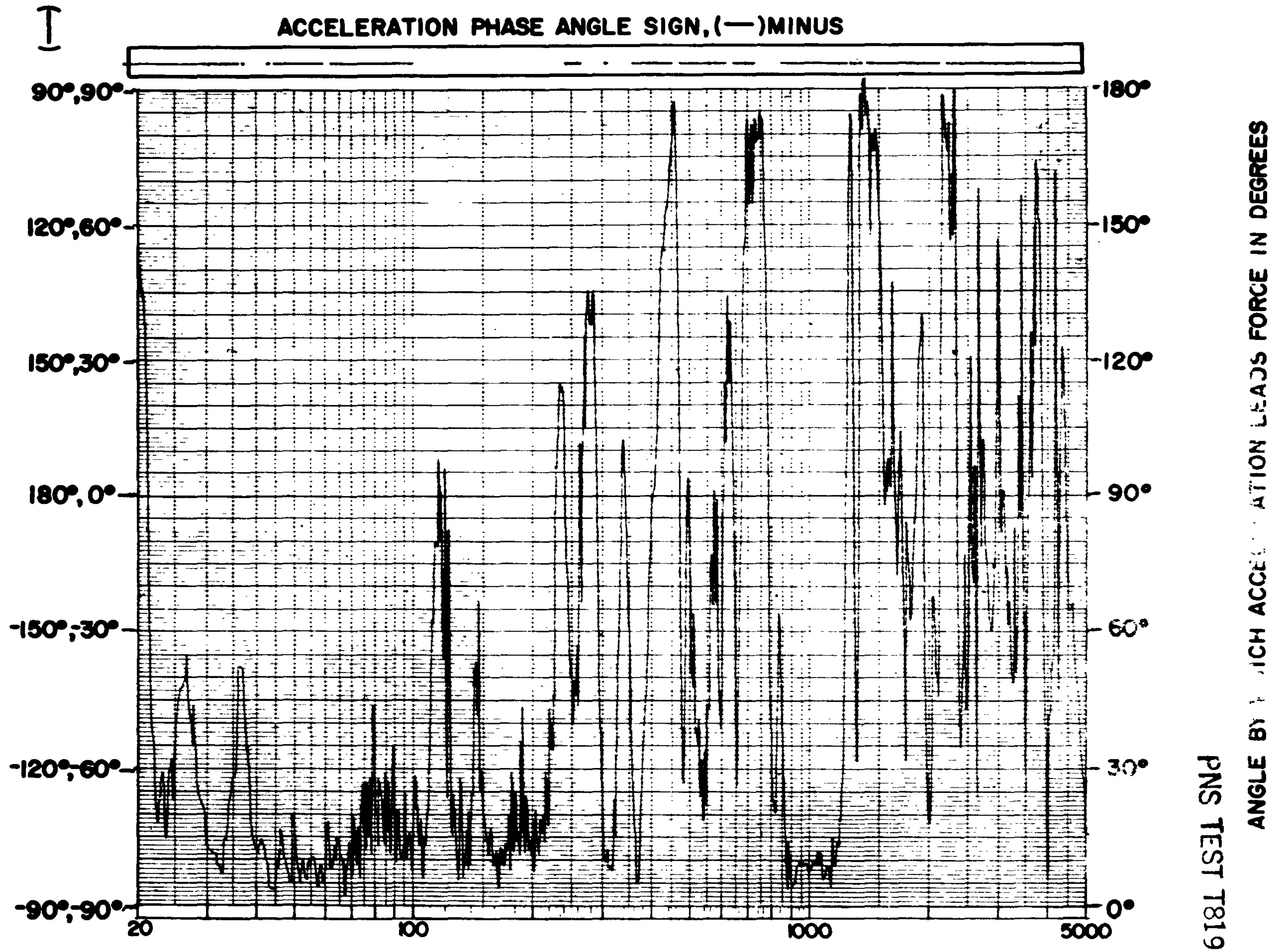
PNS TEST T819 029

IND-PNS-1751 (NEW 5-62)

30


DECIBELS
STIFFNESS, LB/IN
MASS, LB(WEIGHT)
FREQUENCY, CPS
MECHANICAL IMPEDANCE, LB / IN/SEC
20
100
1000
5000
Z_{24-5}
IND-PNS-1750 (NEW 5-62)

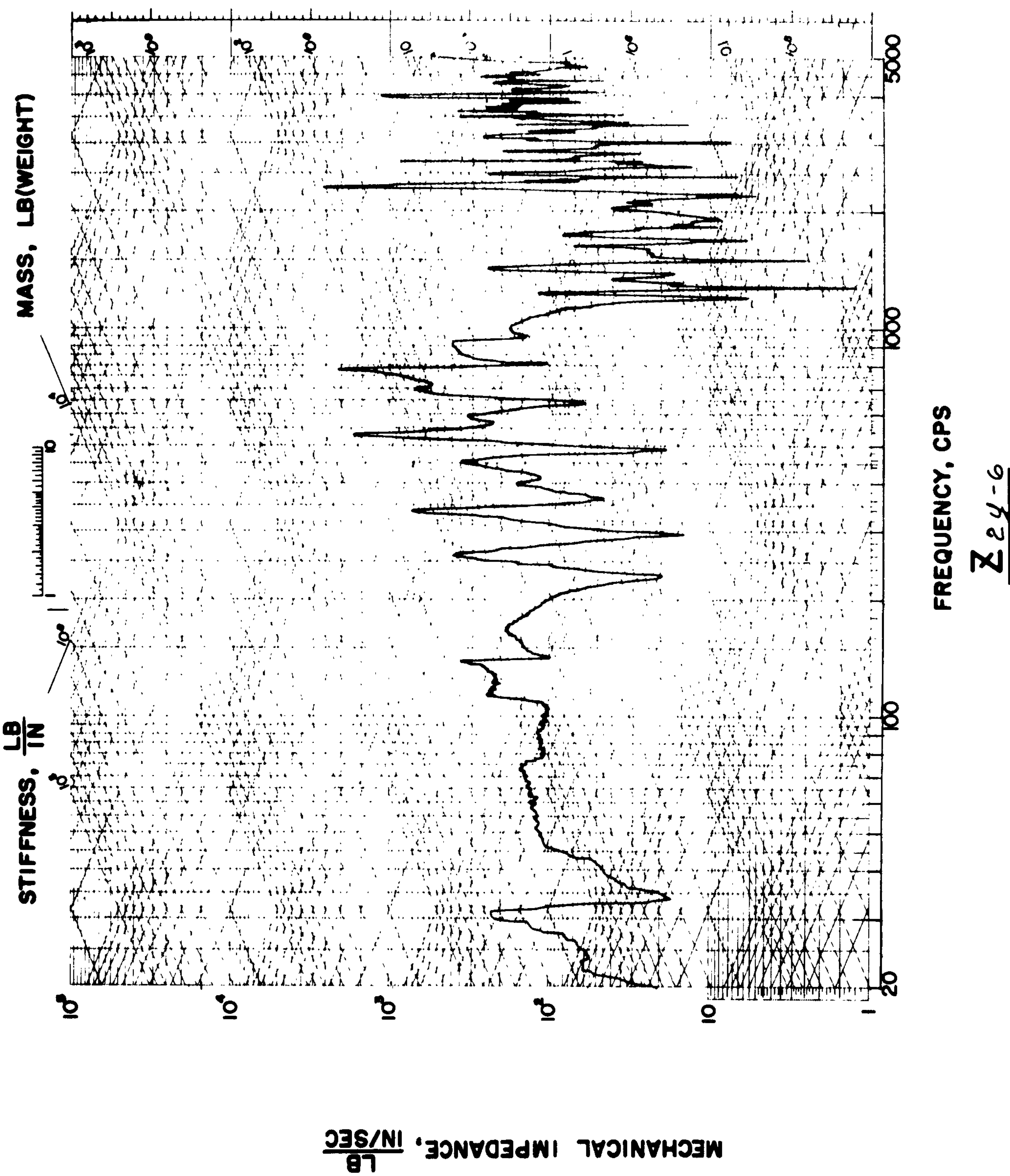
30



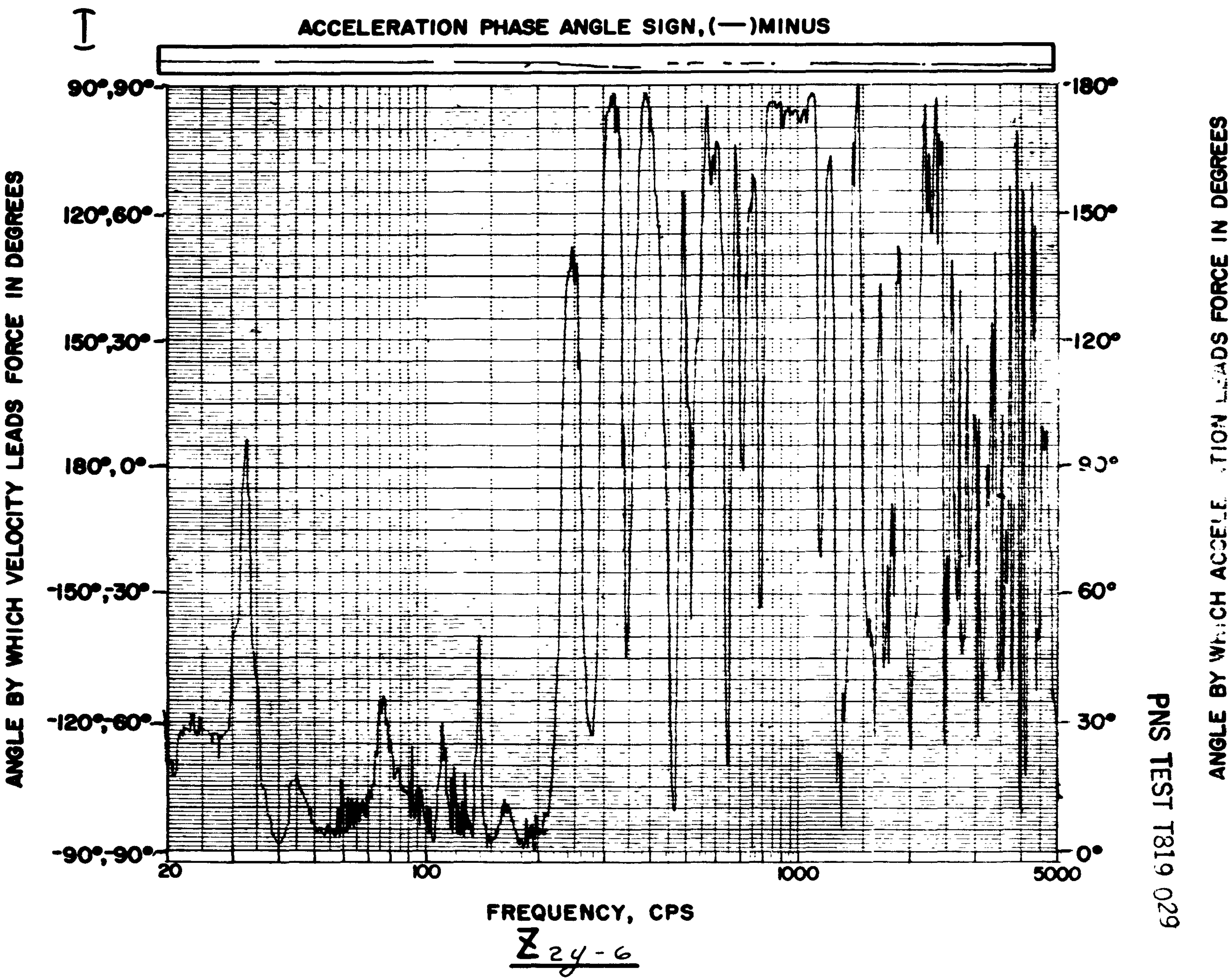
$Z_{2y\text{-}5}$

PNS TEST T819 029

IND-PNS-1751 (NEW 5-62)


STIFFNESS, LB/IN
MASS, LB(WEIGHT)
FREQUENCY, CPS
MECHANICAL IMPEDANCE, LB / IN/SEC
$Z_{2y\text{-}6}$
20
100
1000
5000

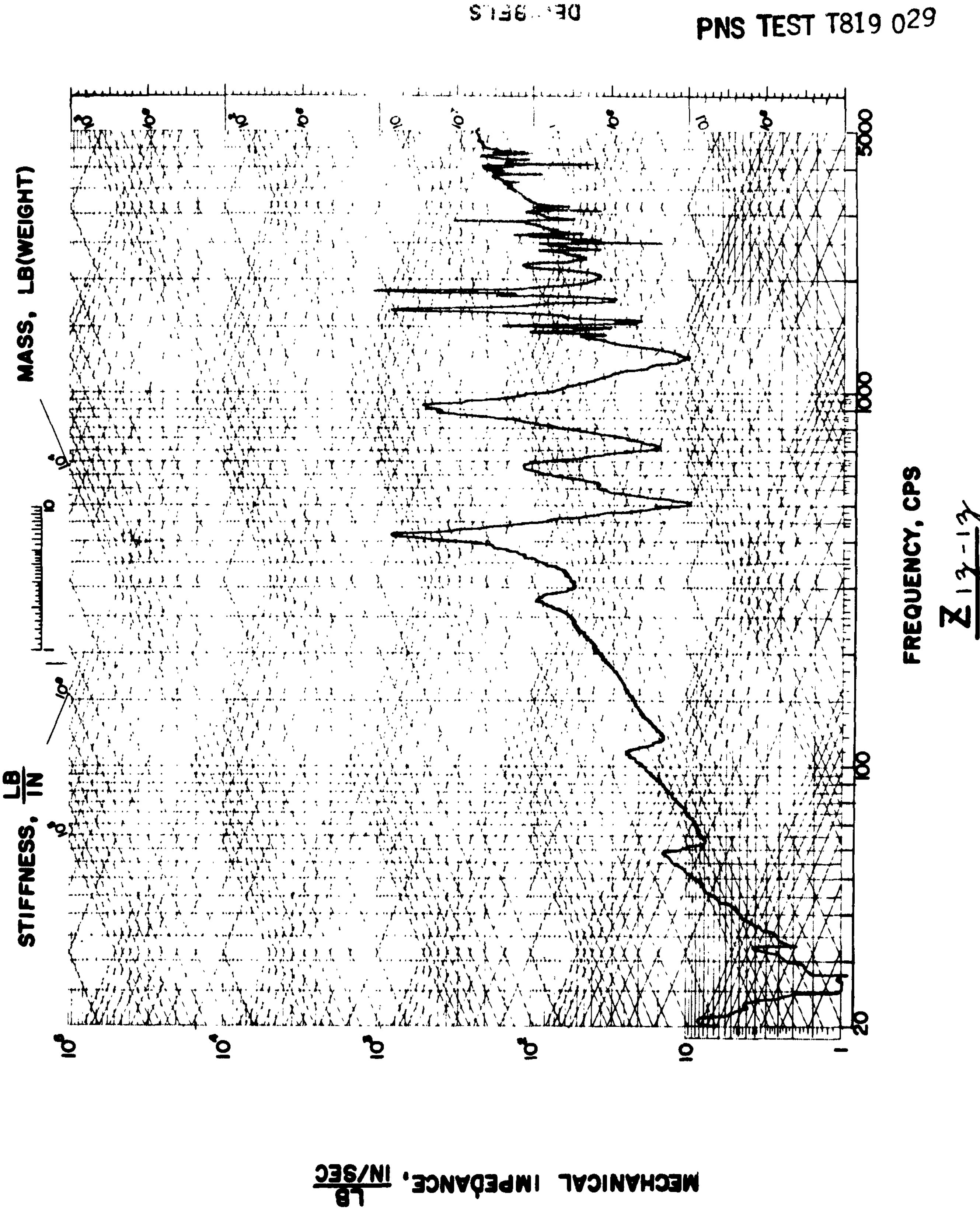
34



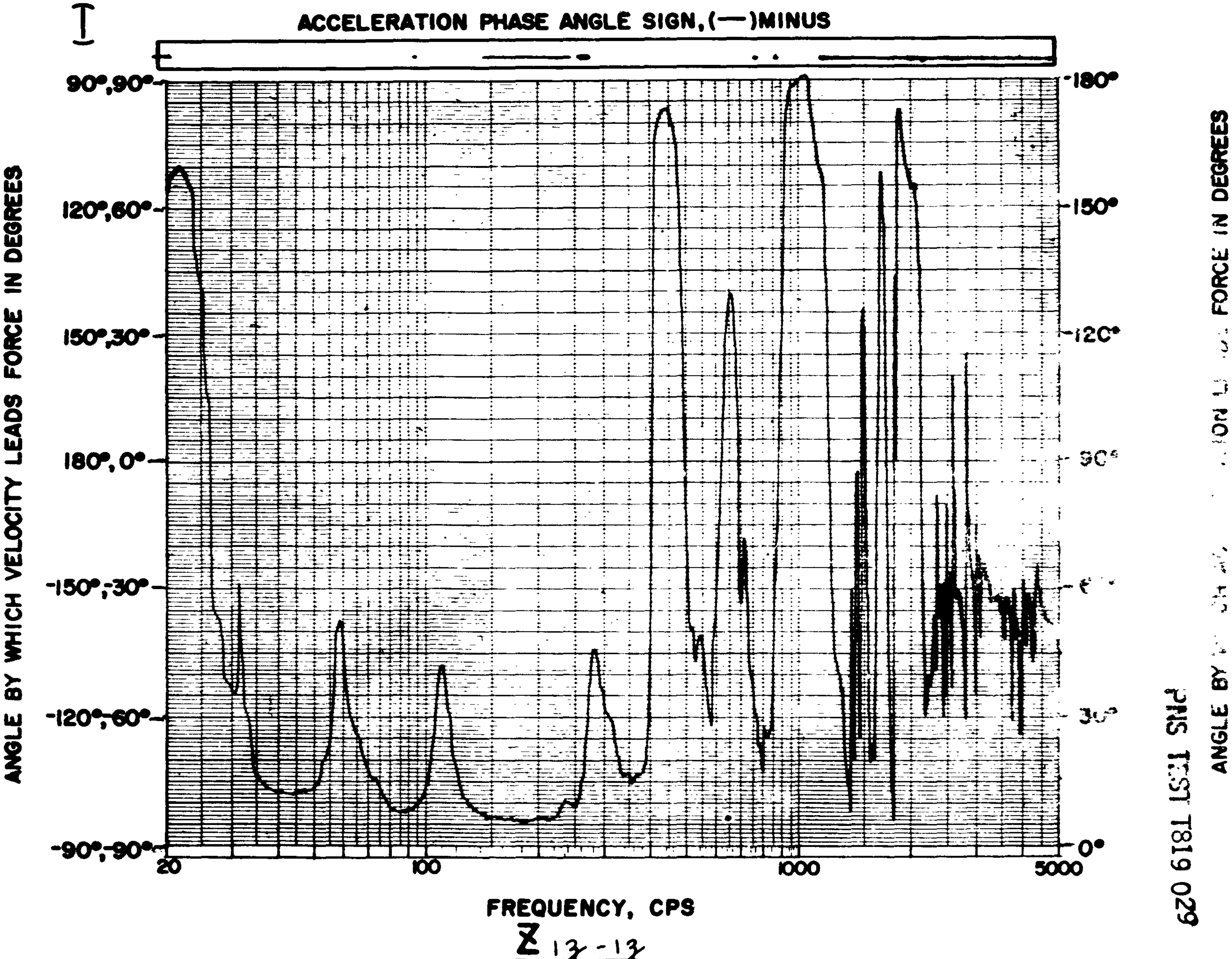
PNS TEST T819 029

15

PNS TEST T819 029

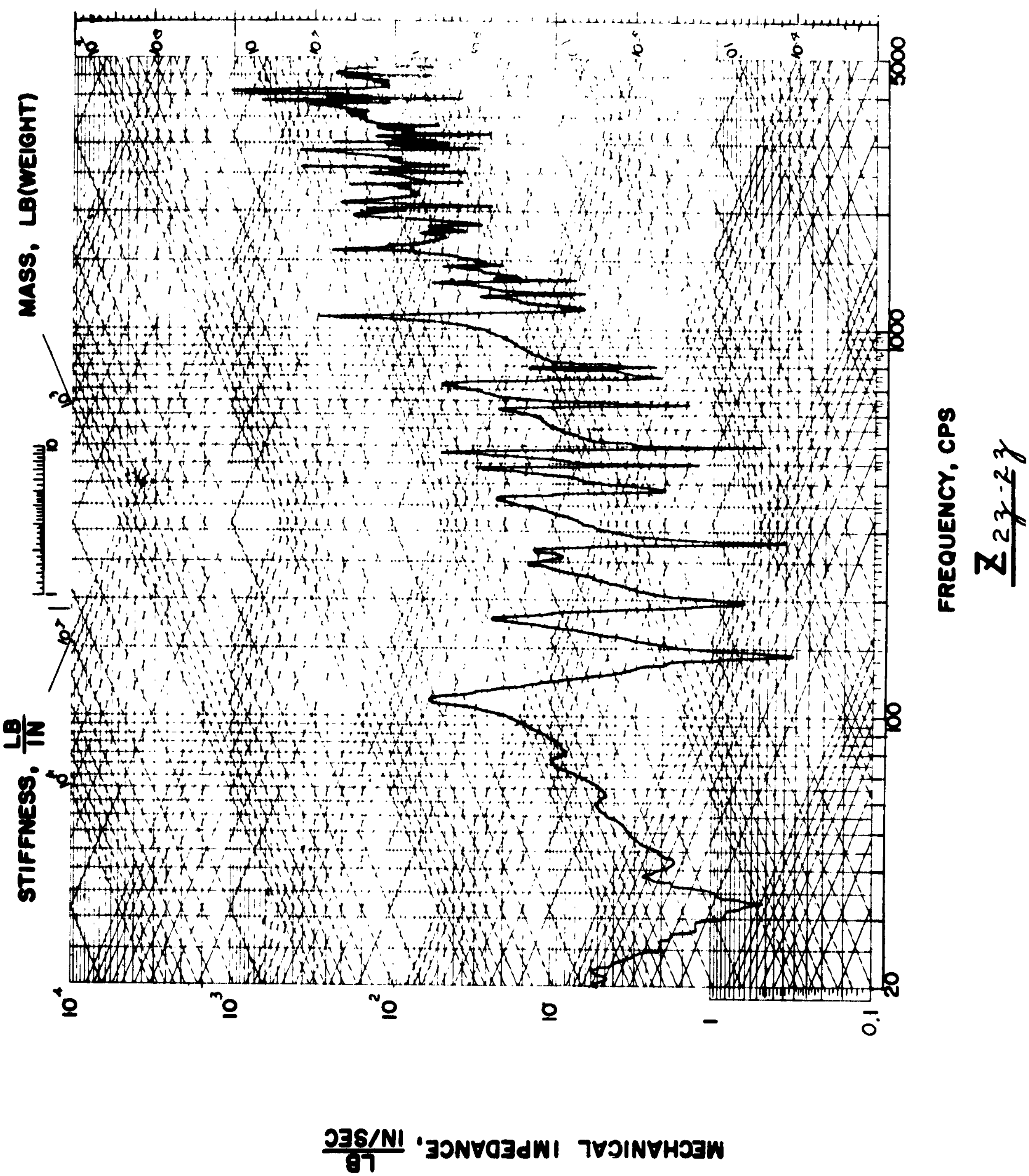


IND-PNS-1750 (NEW 5-62)


I
ACCELERATION PHASE ANGLE SIGN, (—) MINUS
ANGLE BY WHICH VELOCITY LEADS FORCE IN DEGREES
90°,90°
120°,60°
150°,30°
180°, 0°
-150°,-30°
-120°,-60°
-90°,-90°
-180°
-150°
-120°
0°
20
100
1000
5000
FREQUENCY, CPS
Z 13-13
PNS TEST T819 029

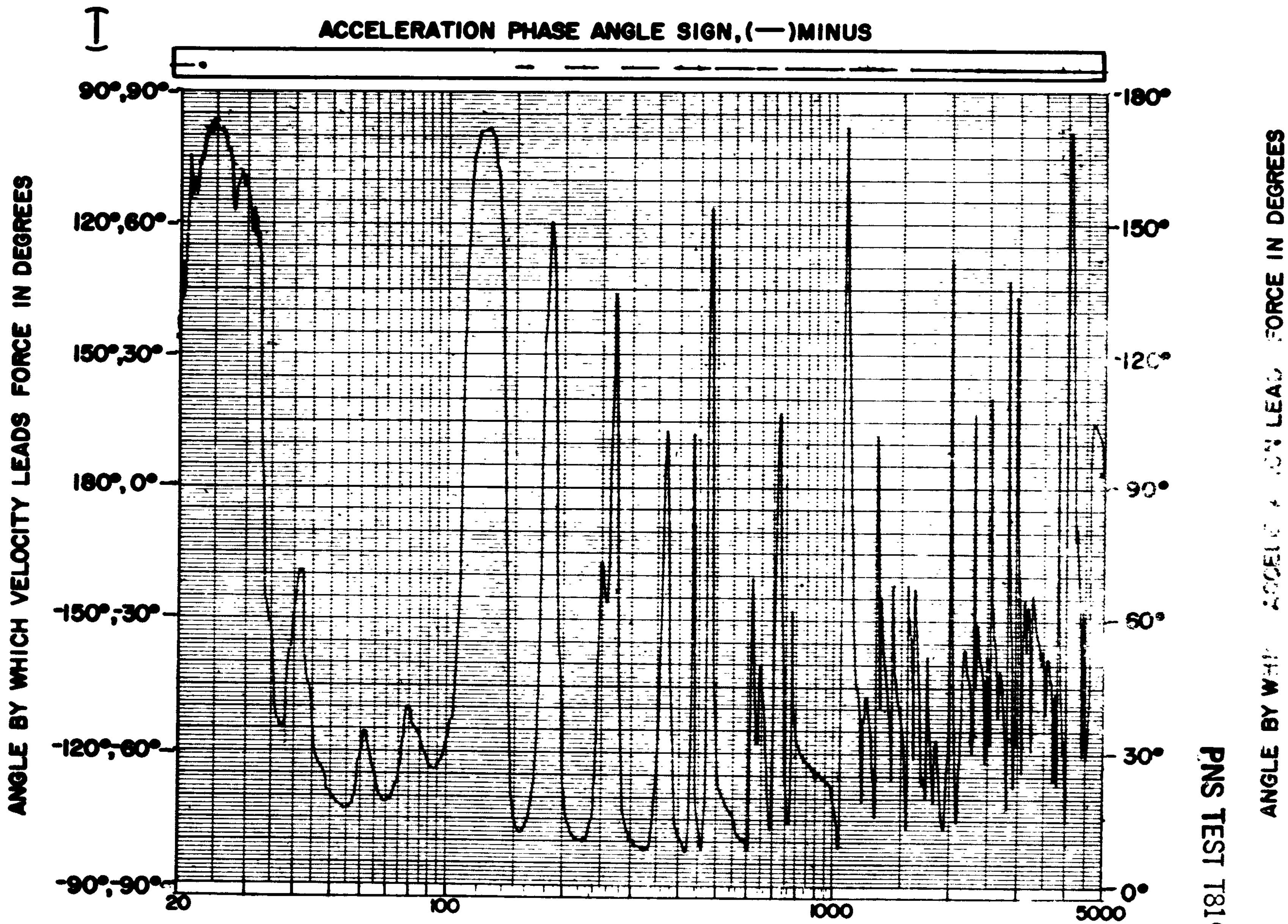
17
$(\times 10^{-1})$

PNS TEST T819 029



IND-PNS-1750 (NEW 5-62)

17

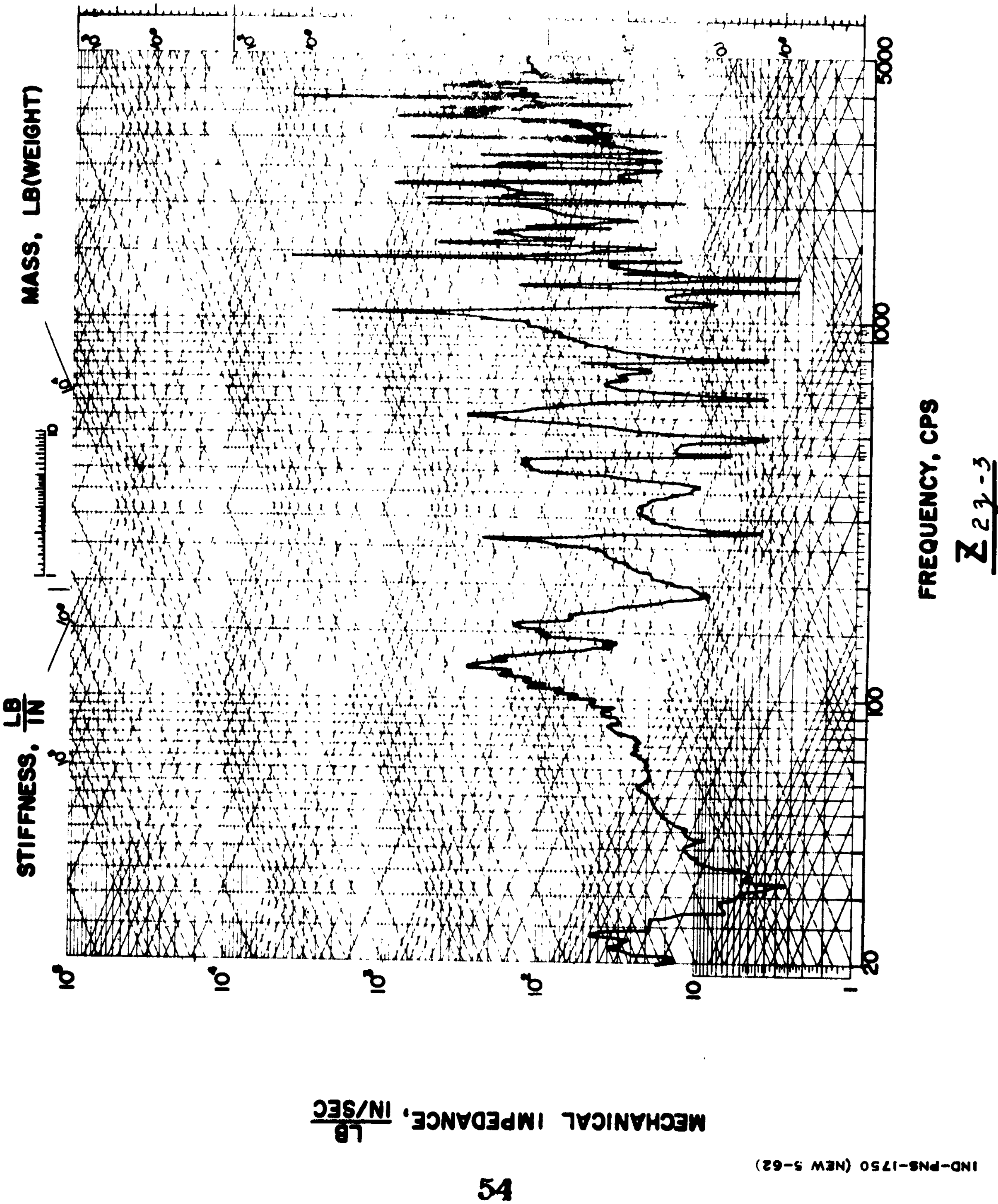


Z_{23-23}

PNS TEST T819 029

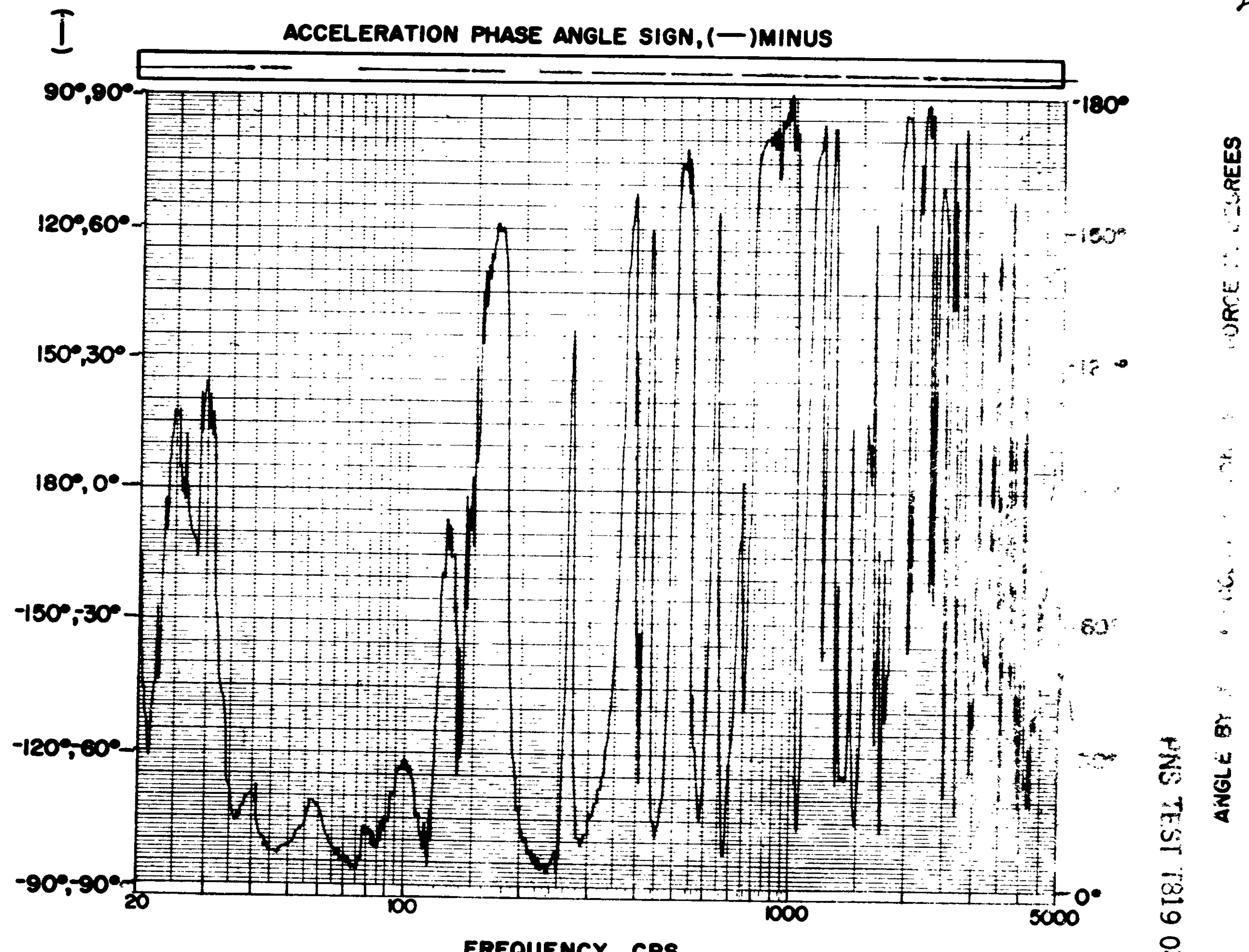
IND-PNS-1751 (NEW 5-62)

53



IND-PNS-1750 (NEW 5-62)

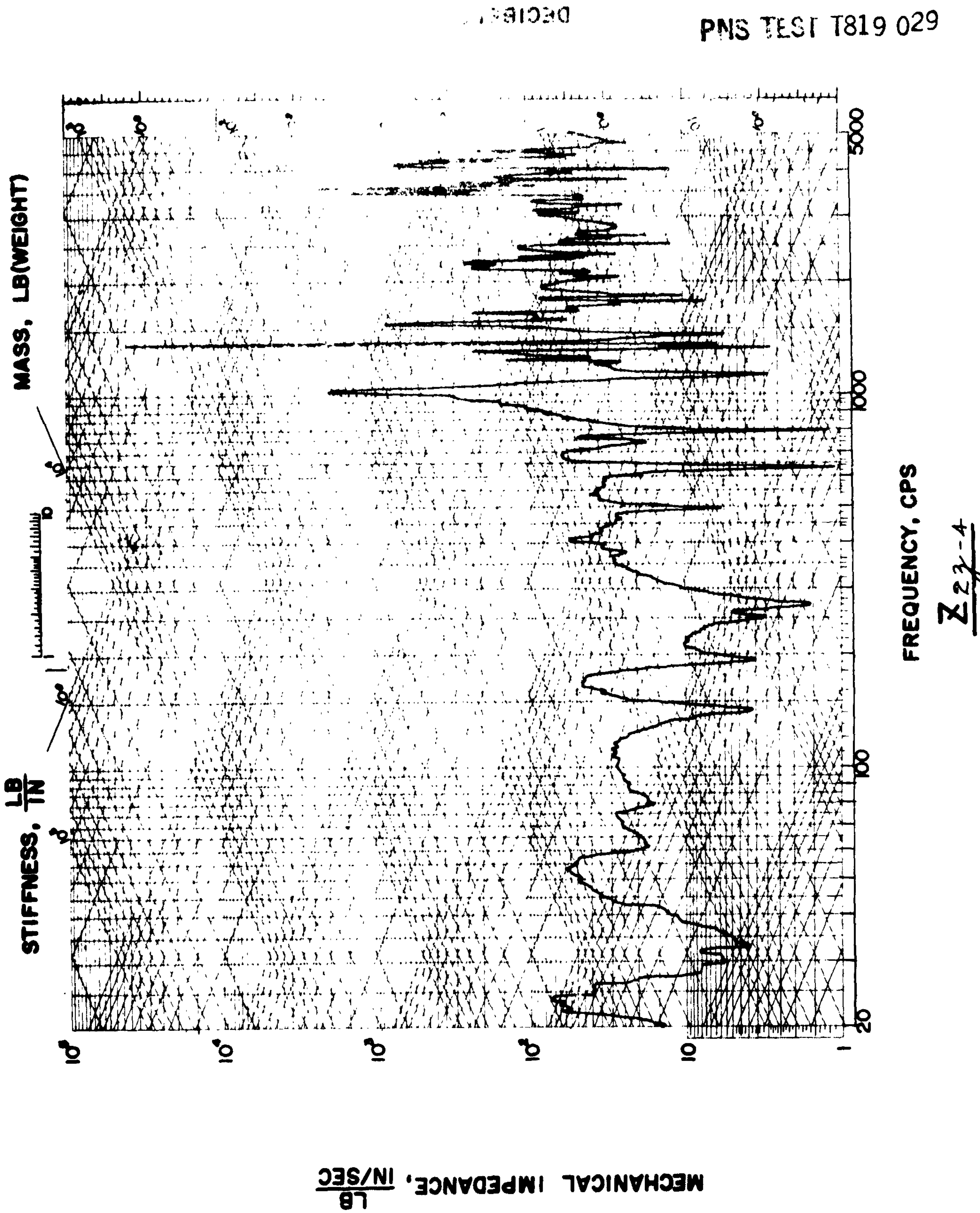
23


ACCELERATION PHASE ANGLE SIGN, (—) MINUS
ANGLE BY WHICH VELOCITY LEADS FORCE IN DEGREES
90°,90°
120°,60°
150°,30°
180°,0°
-150°,-30°
-120°,-60°
-90°,-90°
180°
0°
20
100
1000
5000
FREQUENCY, CPS
PNS TEST T819 029

Z_{23-3}

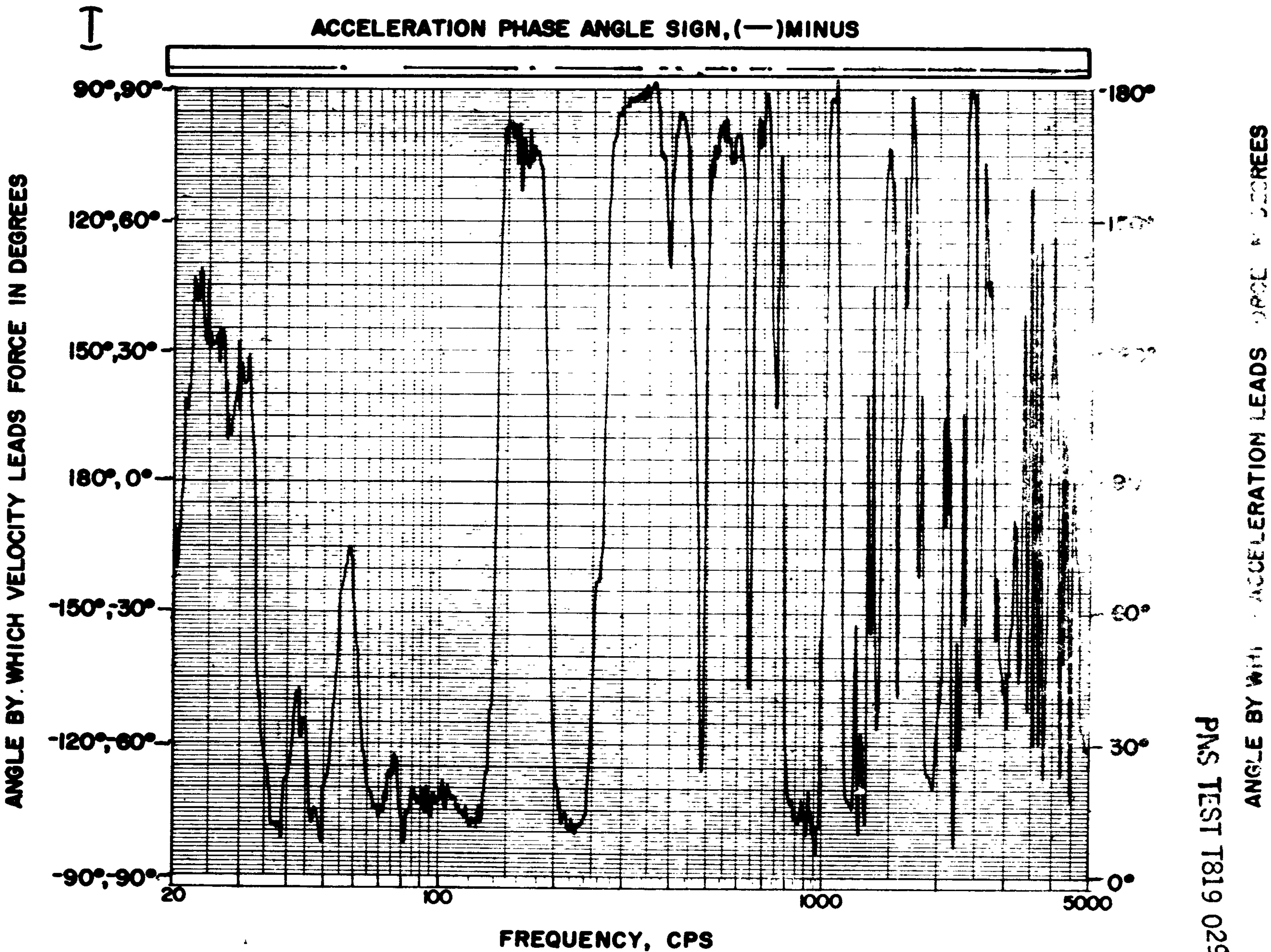
27

PNS TEST T819 029



IND-PNS-1750 (NEW 5-62)

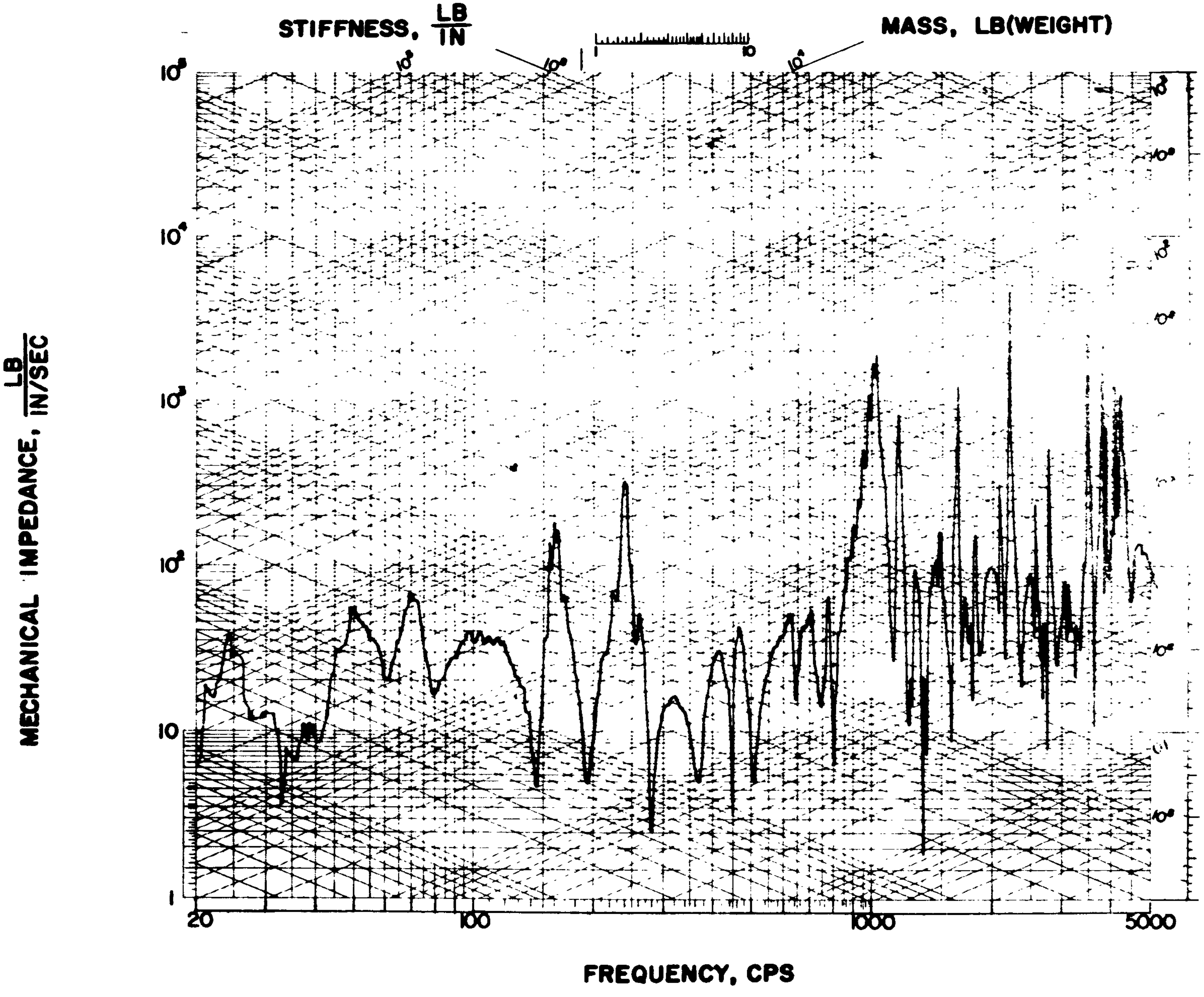
27



Z 23-4

PNS TEST T819 029

IND-PNS-1751 (NEW 5-62)

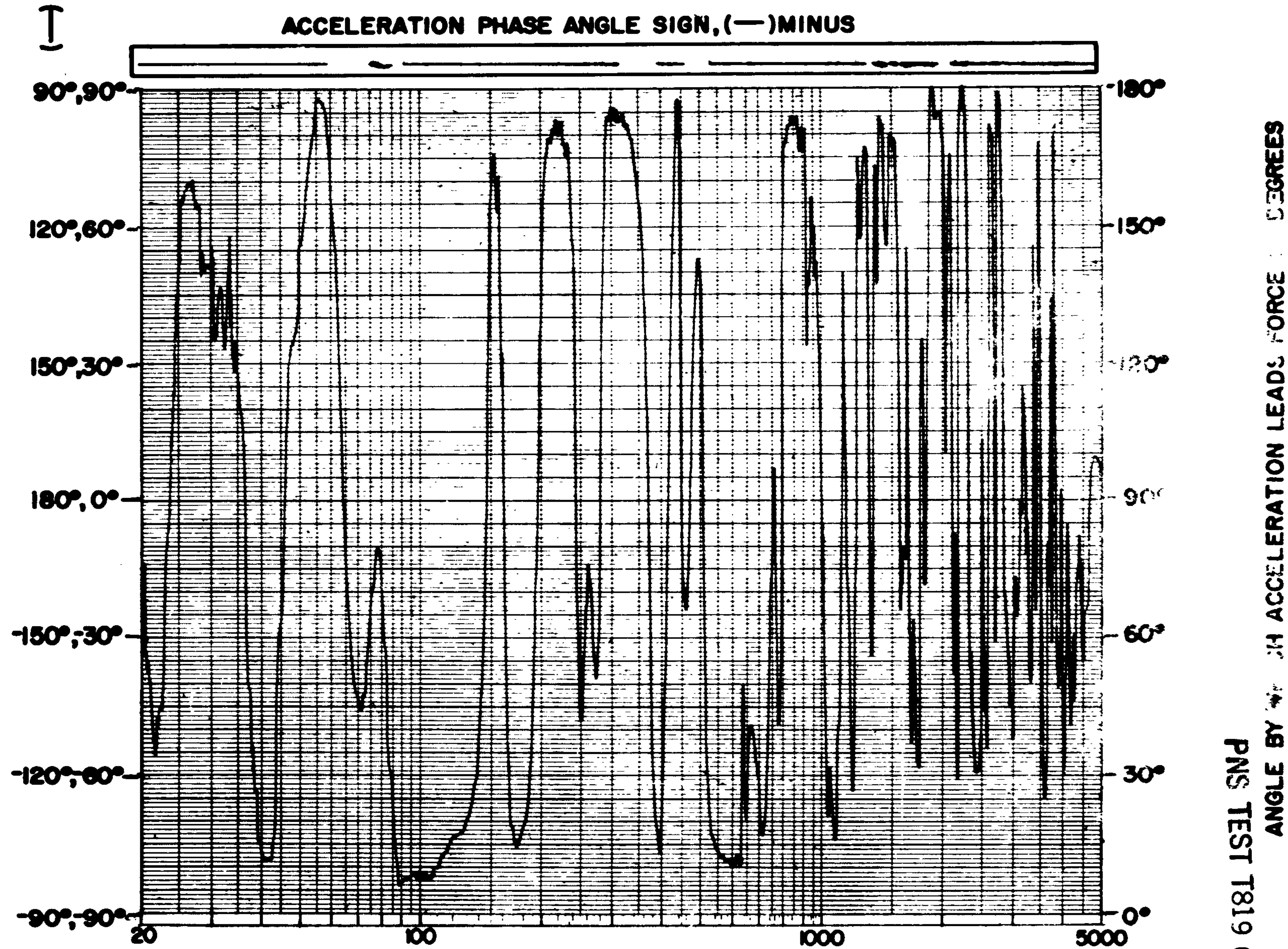


Z_{23-5}

PNS TEST T819 029

IND-PNS-1750 (NEW 5-62)

31



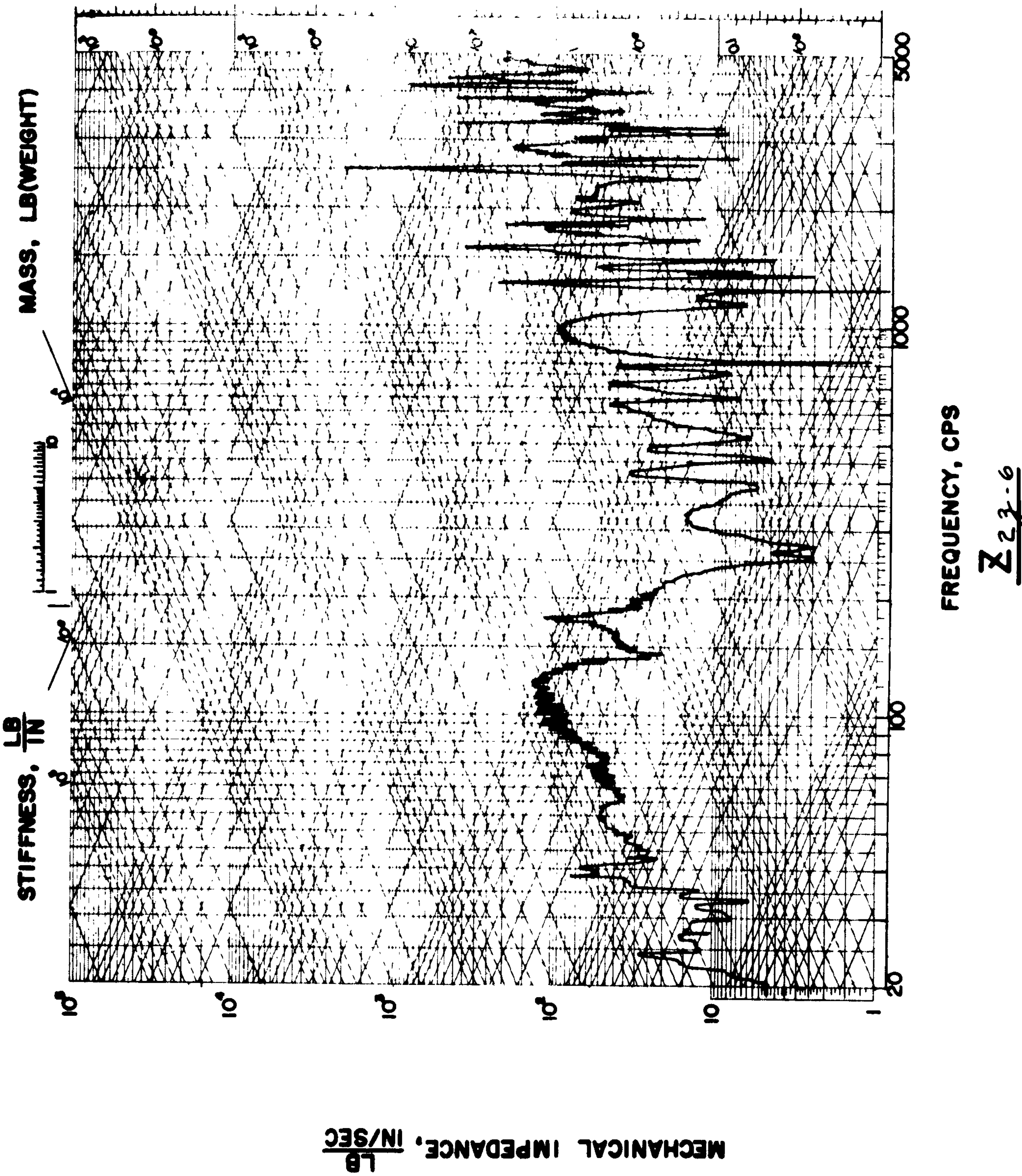
Z_{23-5}

PNS TEST T819 029

IND-PNS-1751 (NEW 5-62)

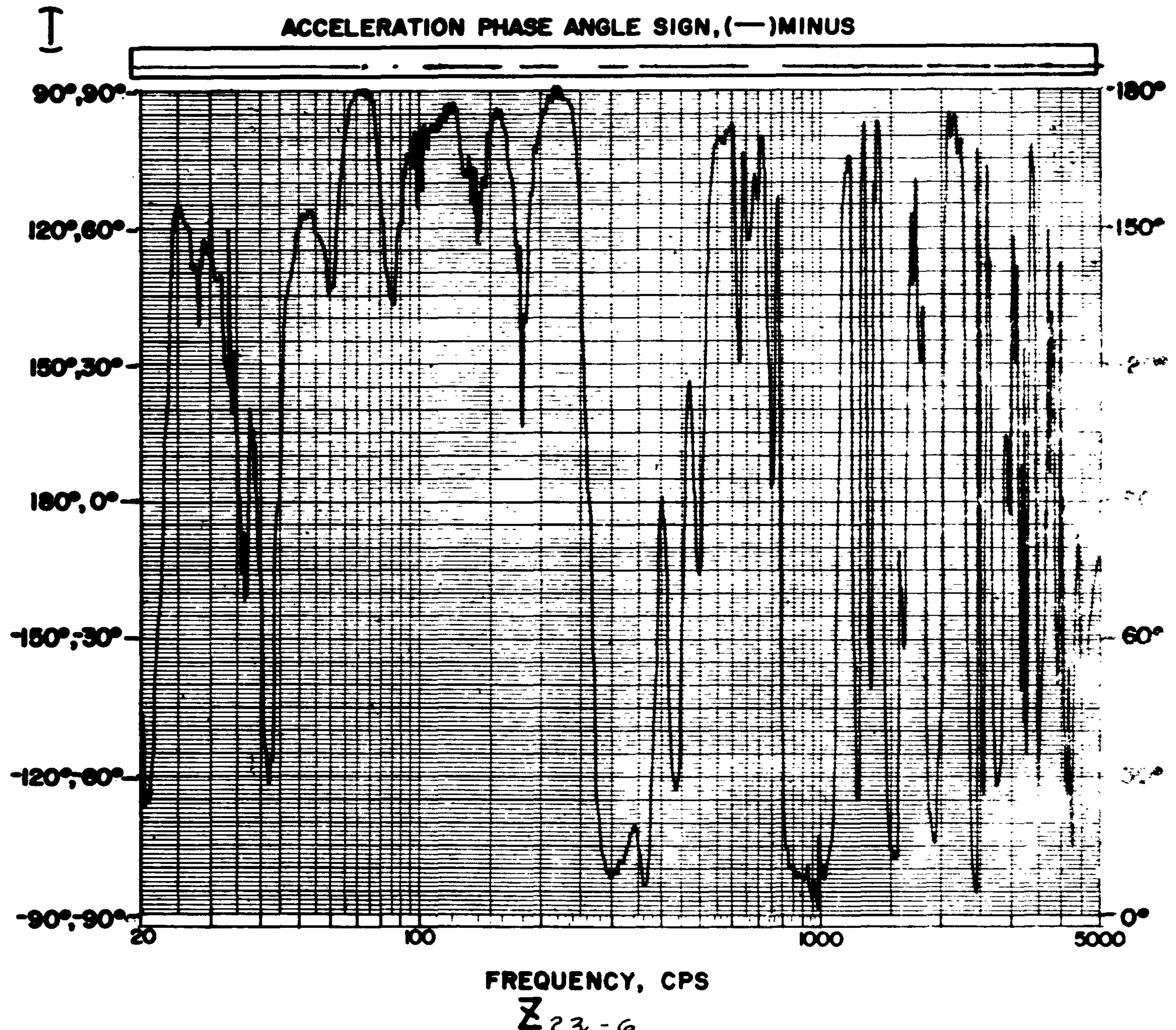
35

PNS TEST T819 029



IND-PNS-1750 (NEW 5-62)

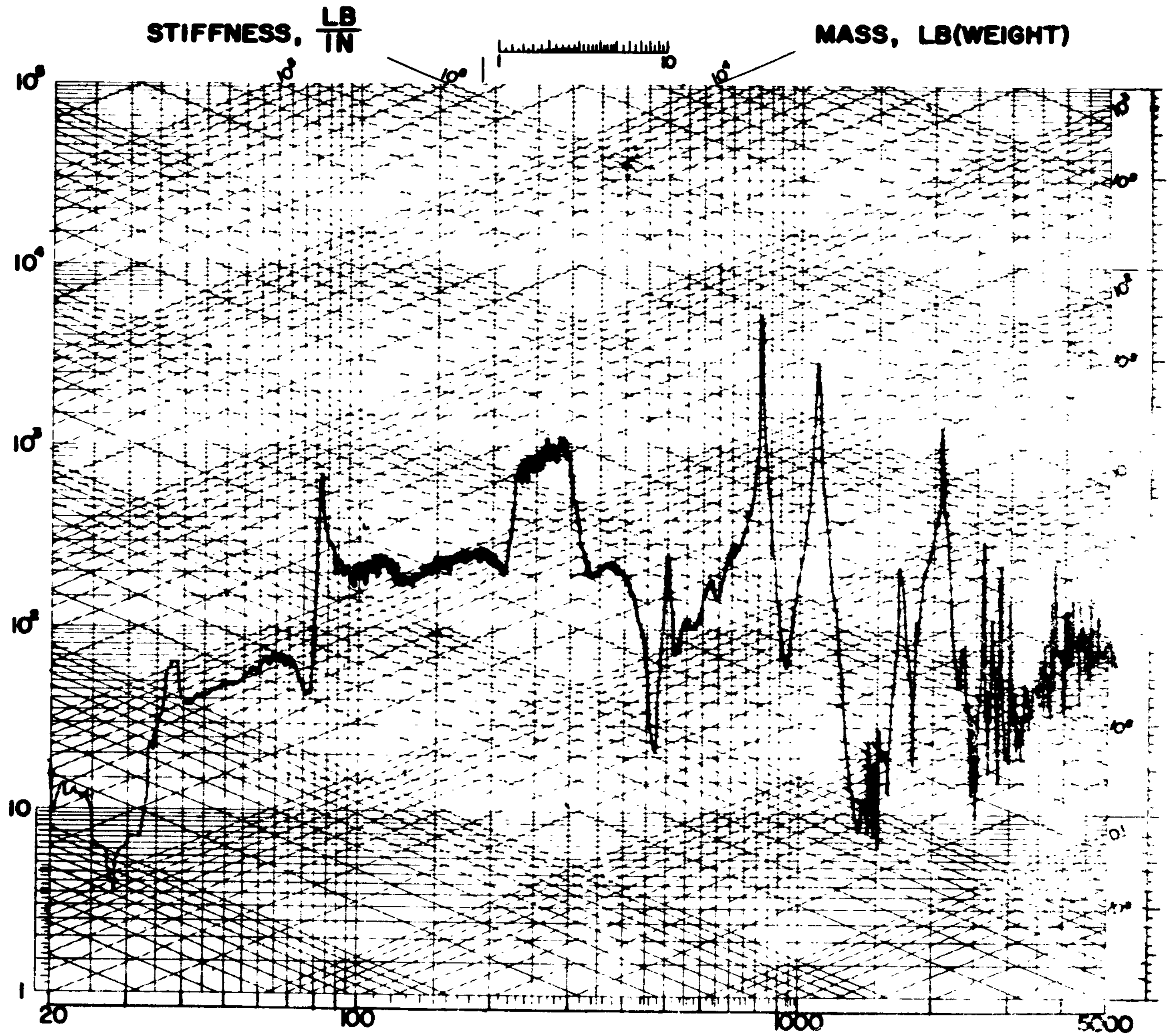
35



ANGLE BY WHICH ACCE... LEADS ...ORCE IN DEGREES

PNS TEST T819 029

2

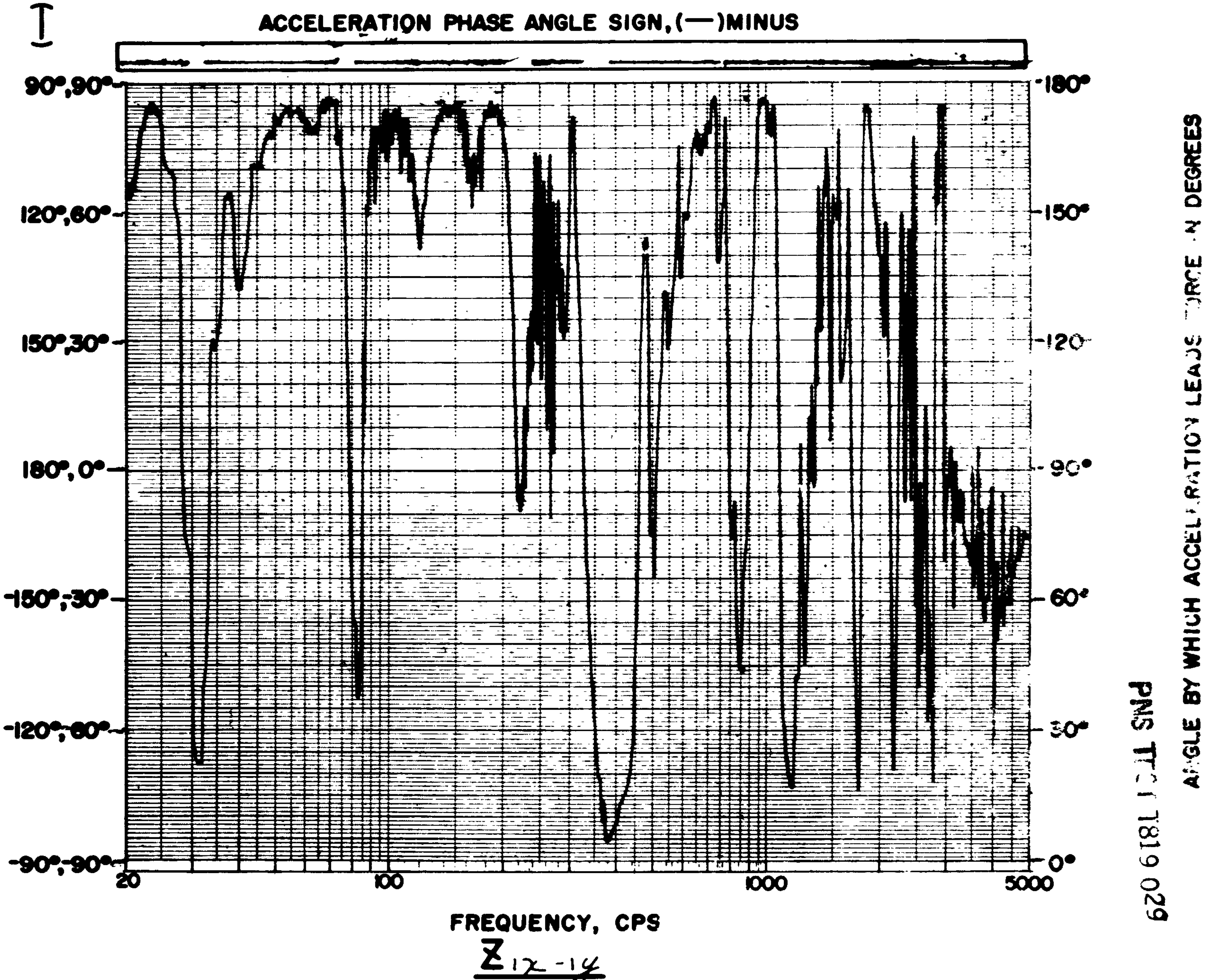


Z_{1x-1y}

62

IND-PNS-1750 (NEW 5-62)

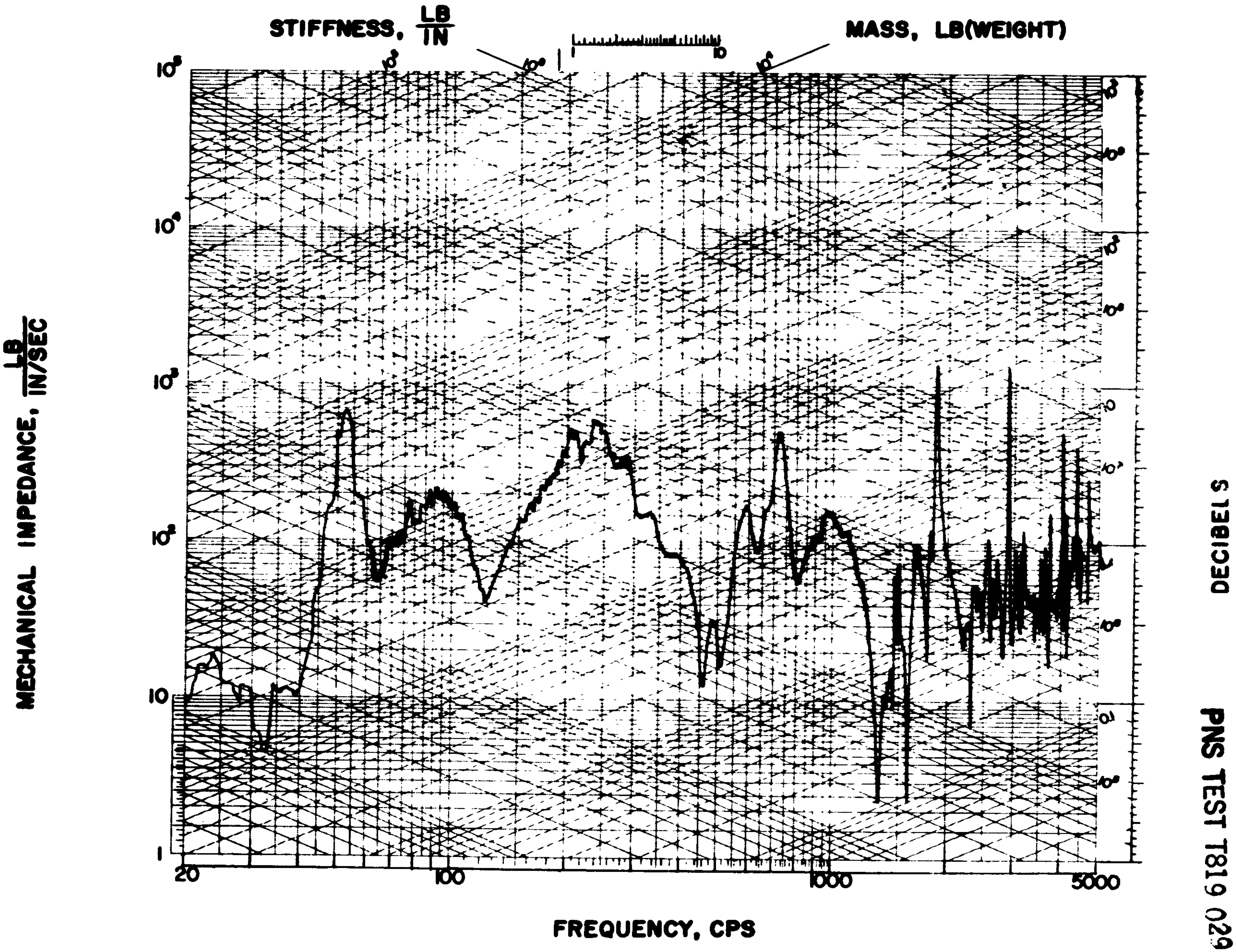
T819 029



2

PNS TT-1 1819 029

IND-PNS-1751 (NEW 5-62)

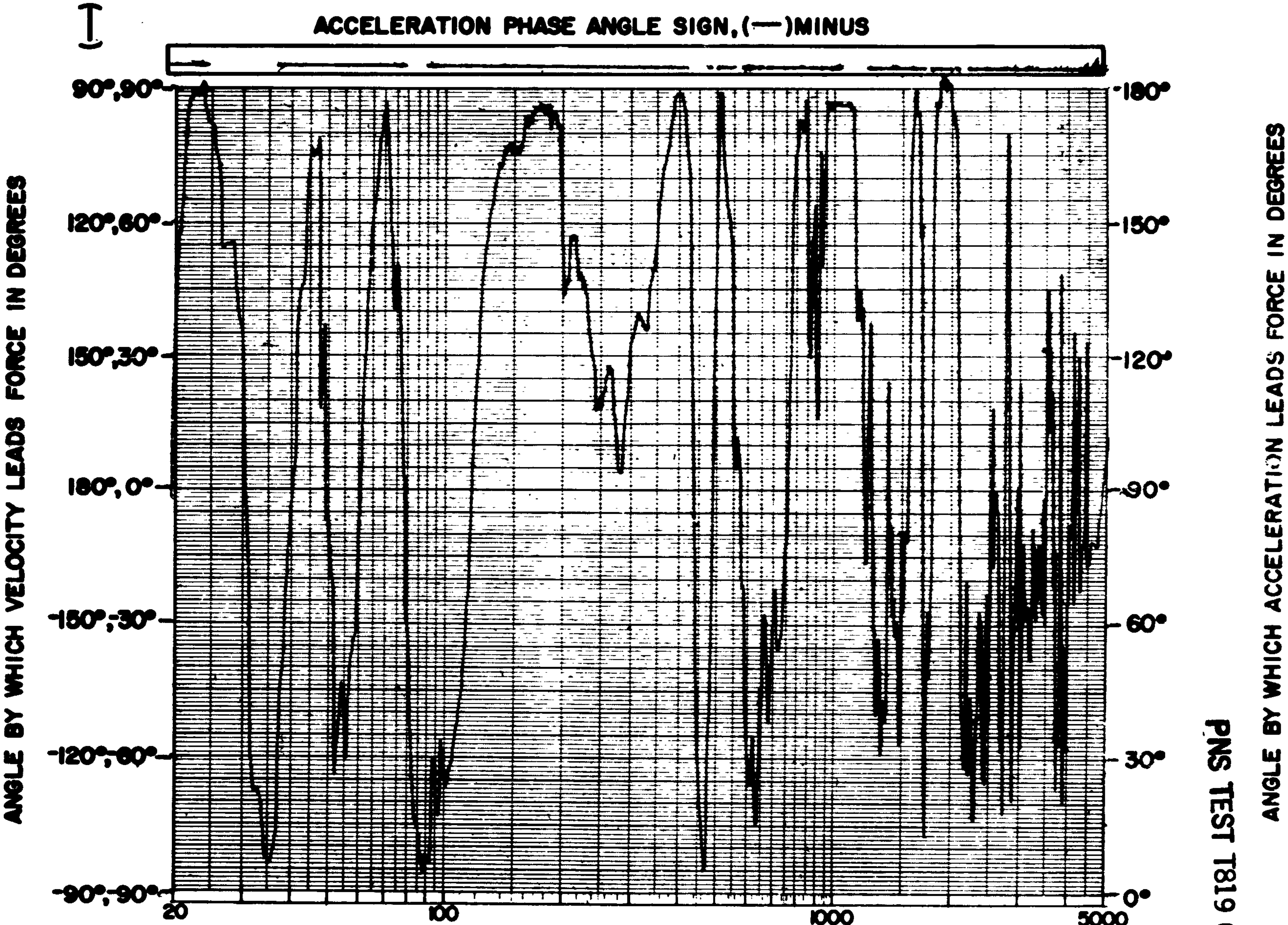


Z_{1x-1z}

PNS TEST T819 029

IND-PNS-1750 (NEW 5-62)

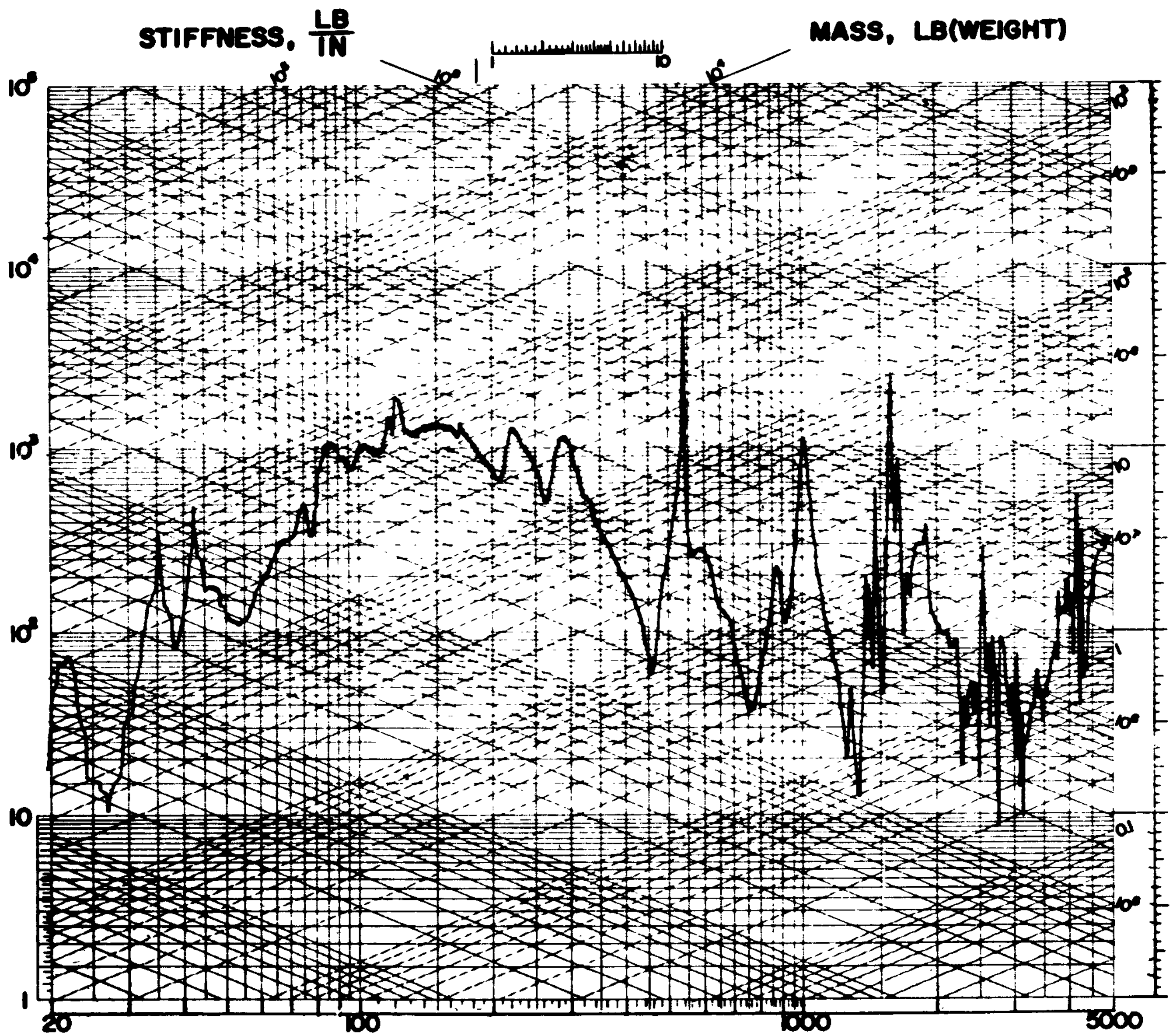
3



PNS TEST T819 029

Z 1X-1Z

10



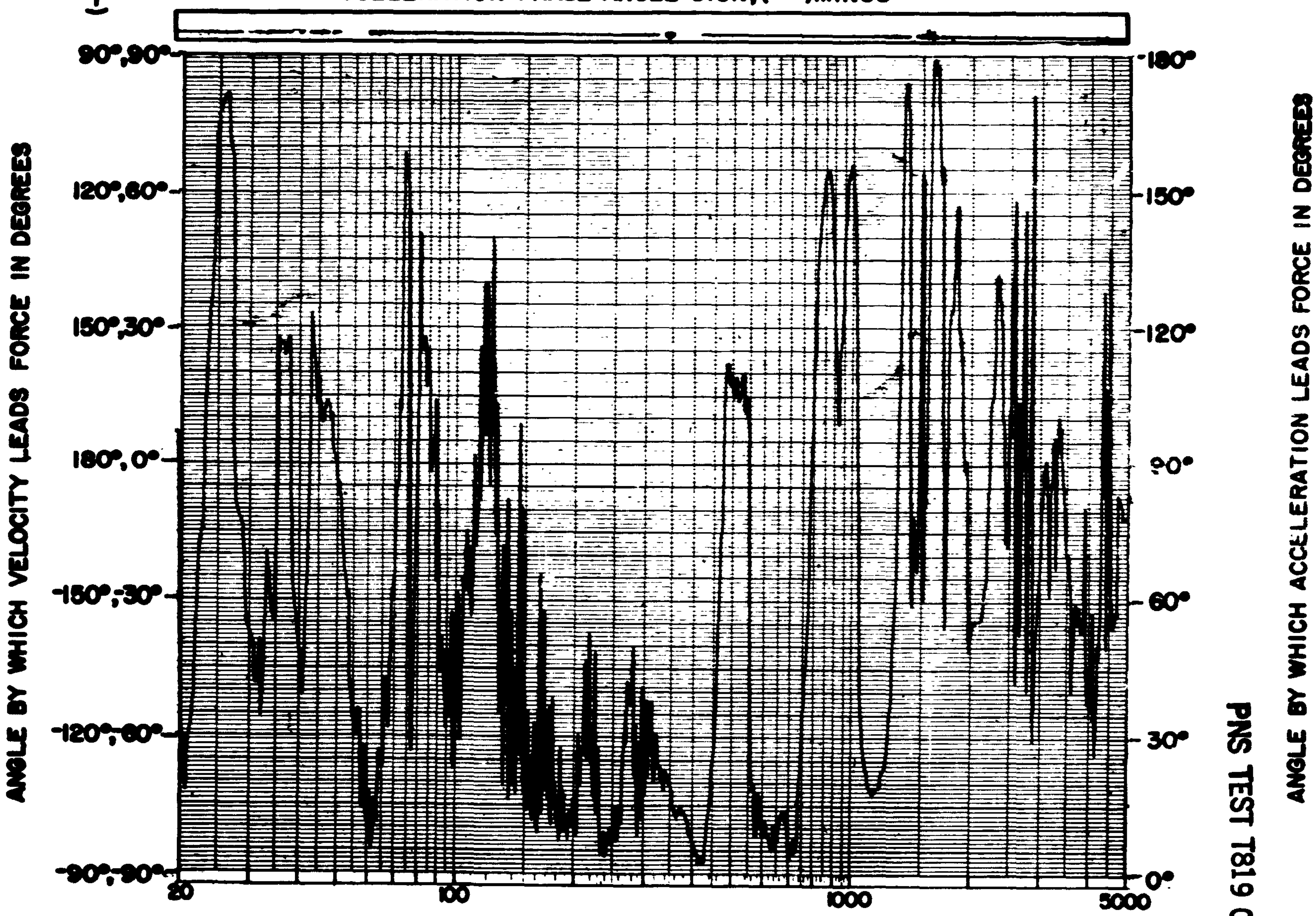
PNS TEST T819 029

Z_{14-13}

IND-PNS-1750 (NEW 5-62)

10

I

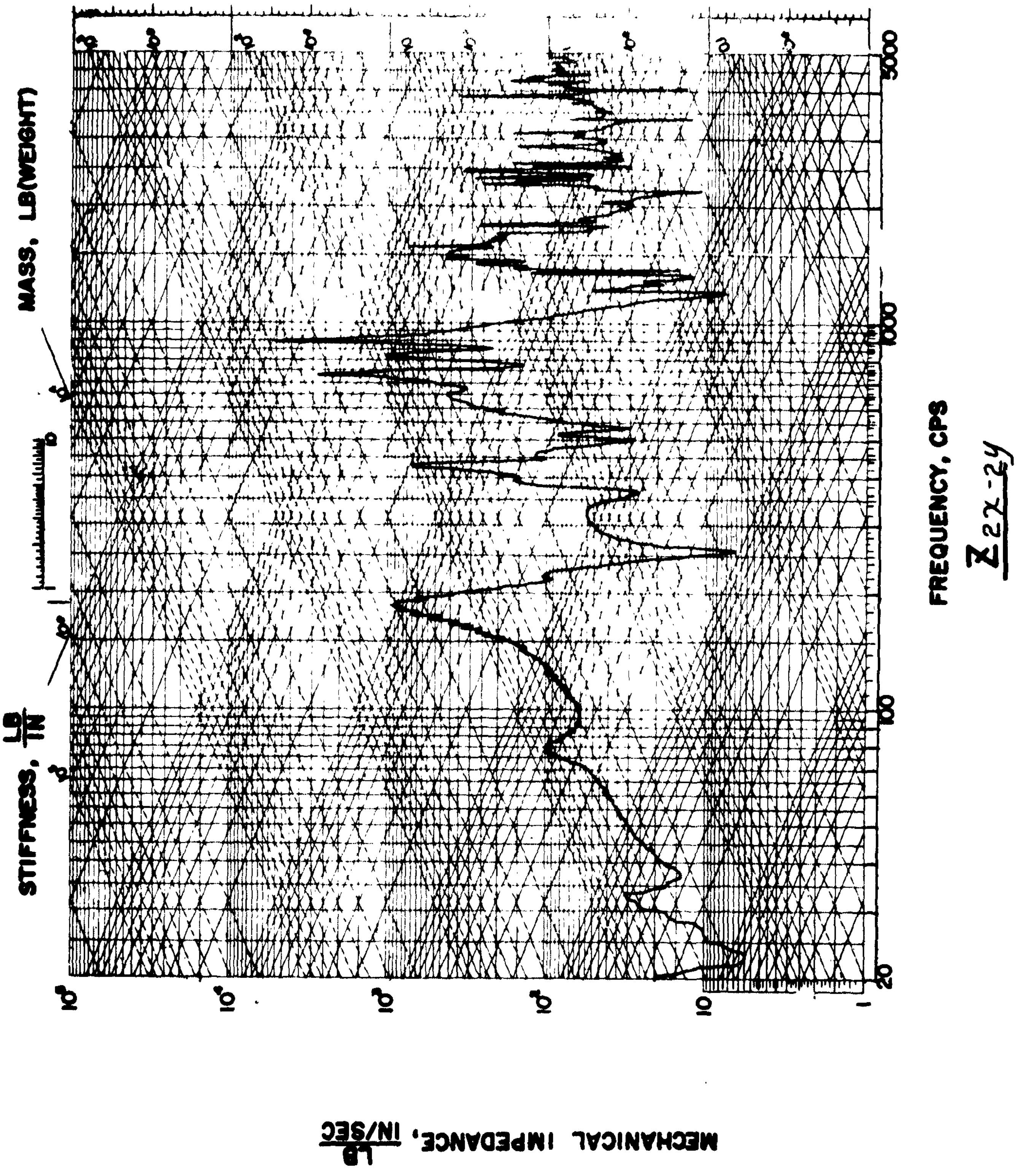


Z_{14-12}

PNS TEST T819 029

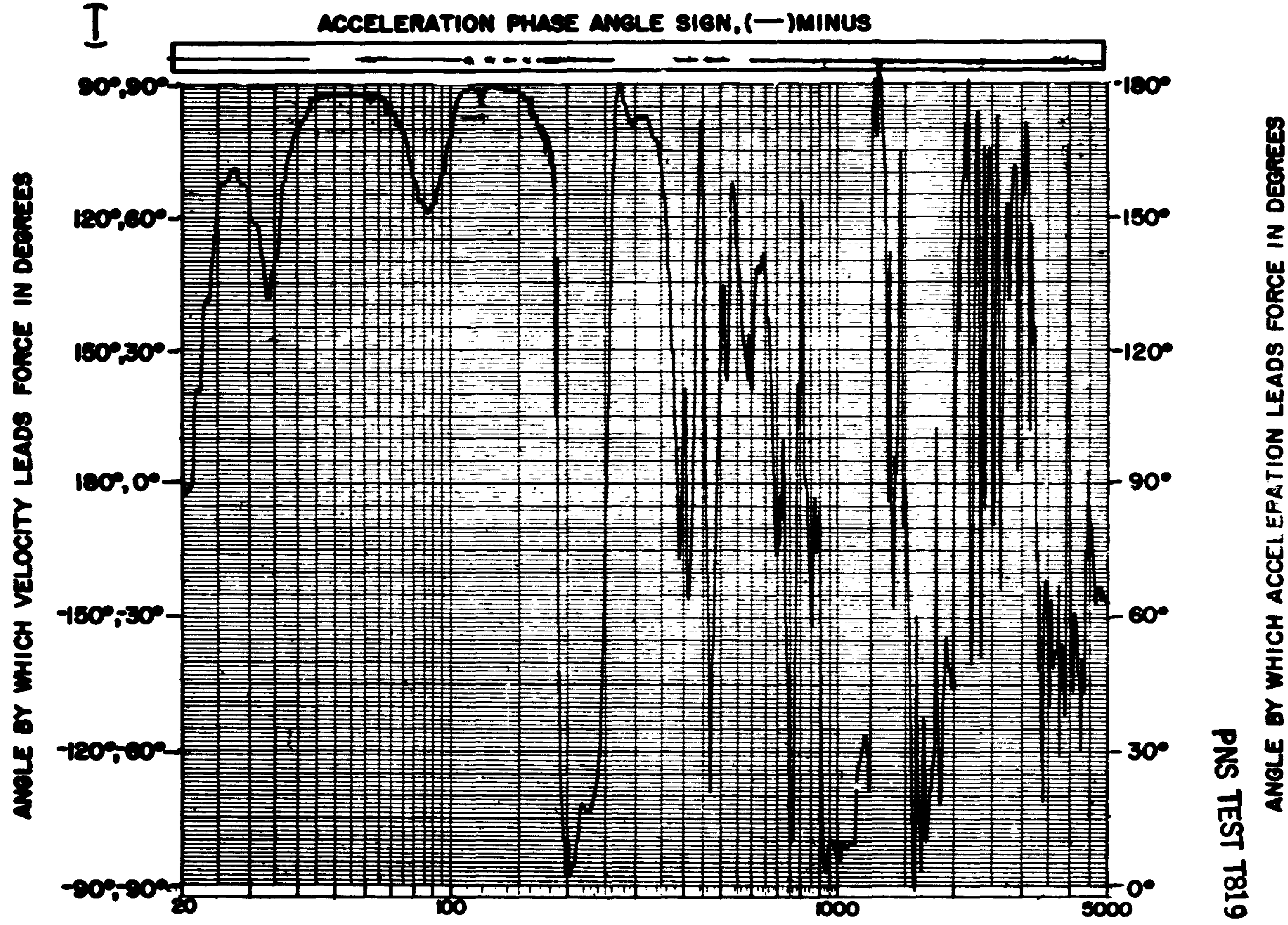
IND-PNS-1751 (NEW 5-62)

PNS TEST T819 029



Z_{2X-24}

I

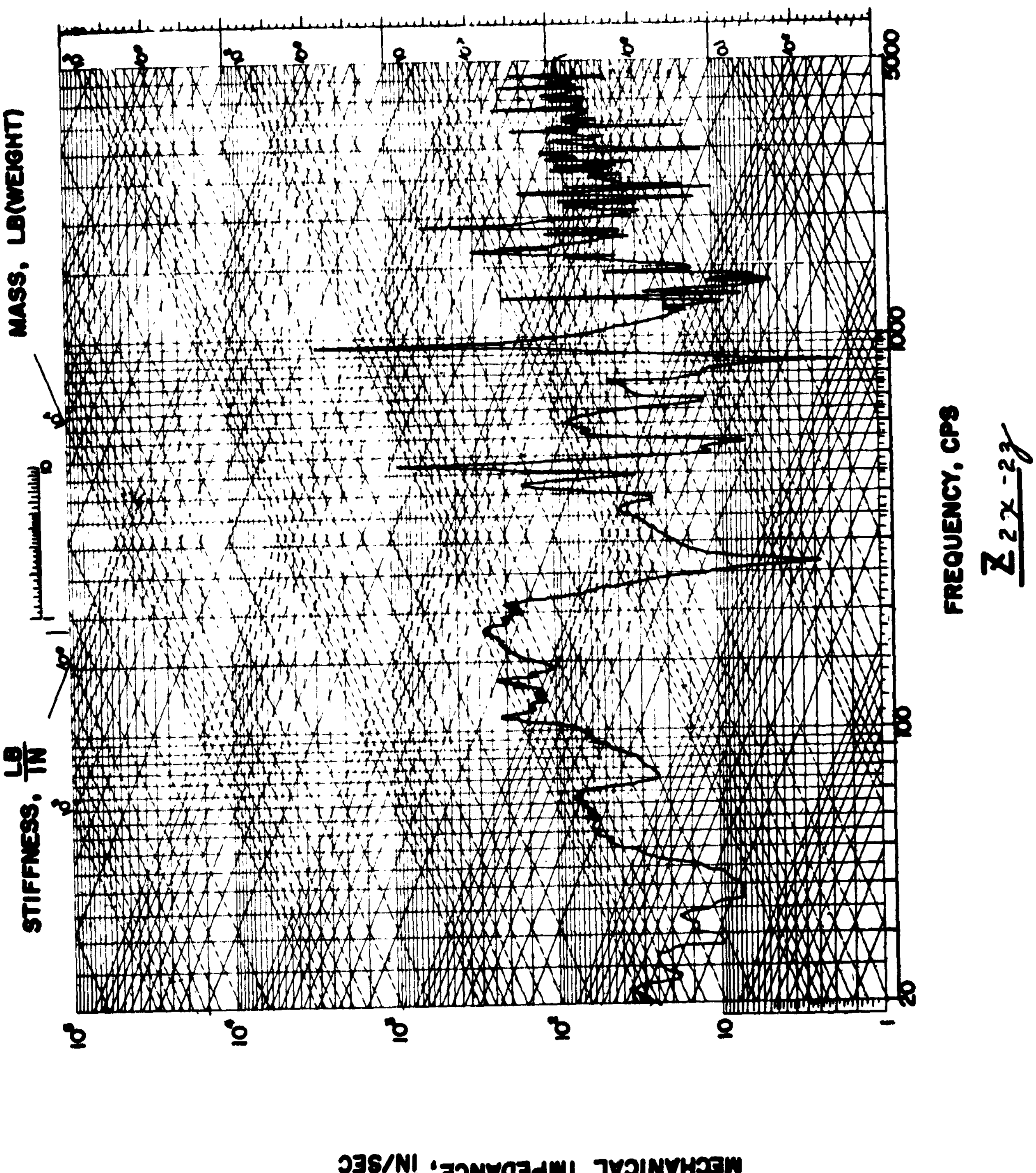


Z_{2x-2y}

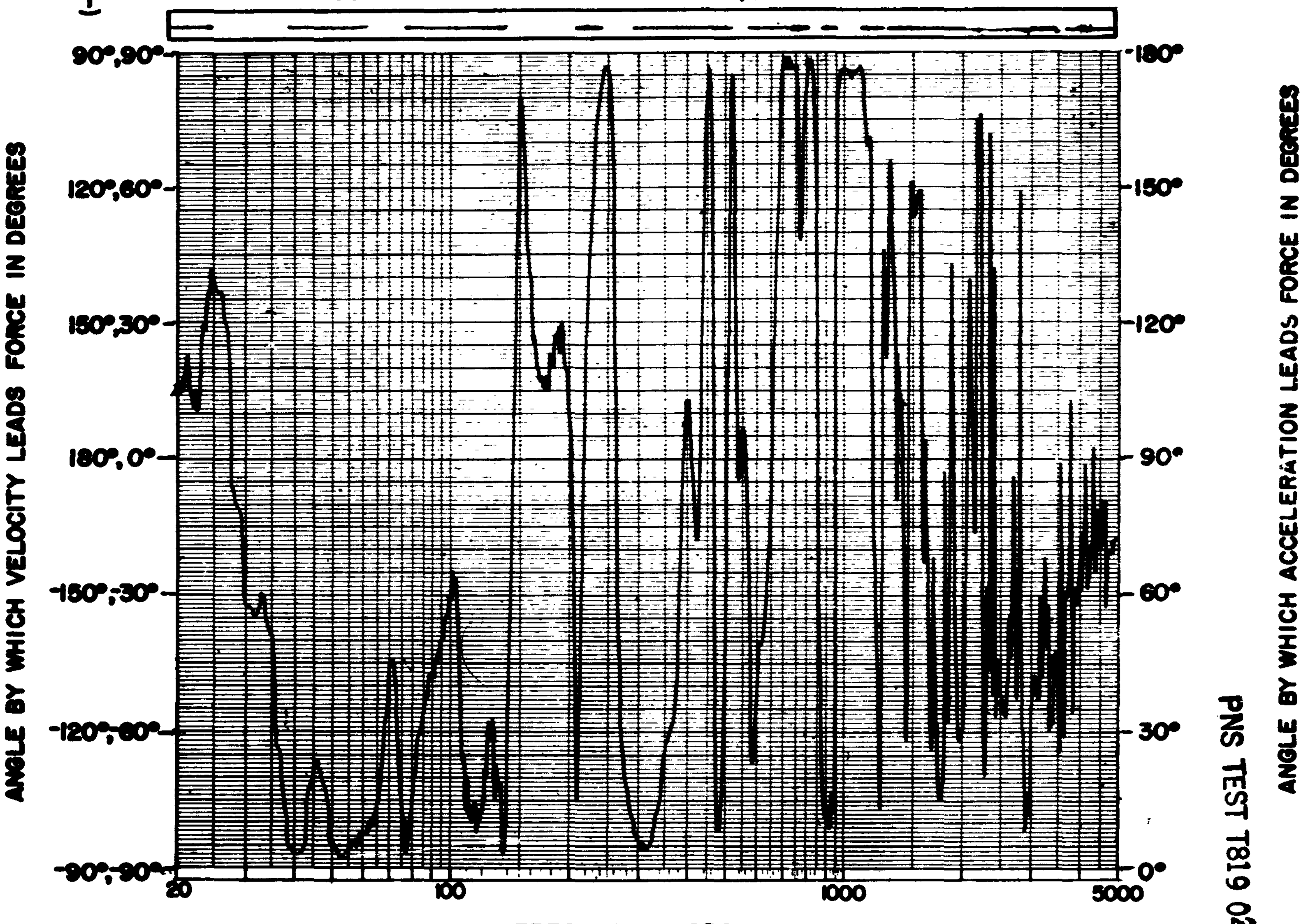
PNS TEST T819 029

IND-PNS-1751 (NEW 5-62)

PNS TEST T819 029



I



FREQUENCY, CPS

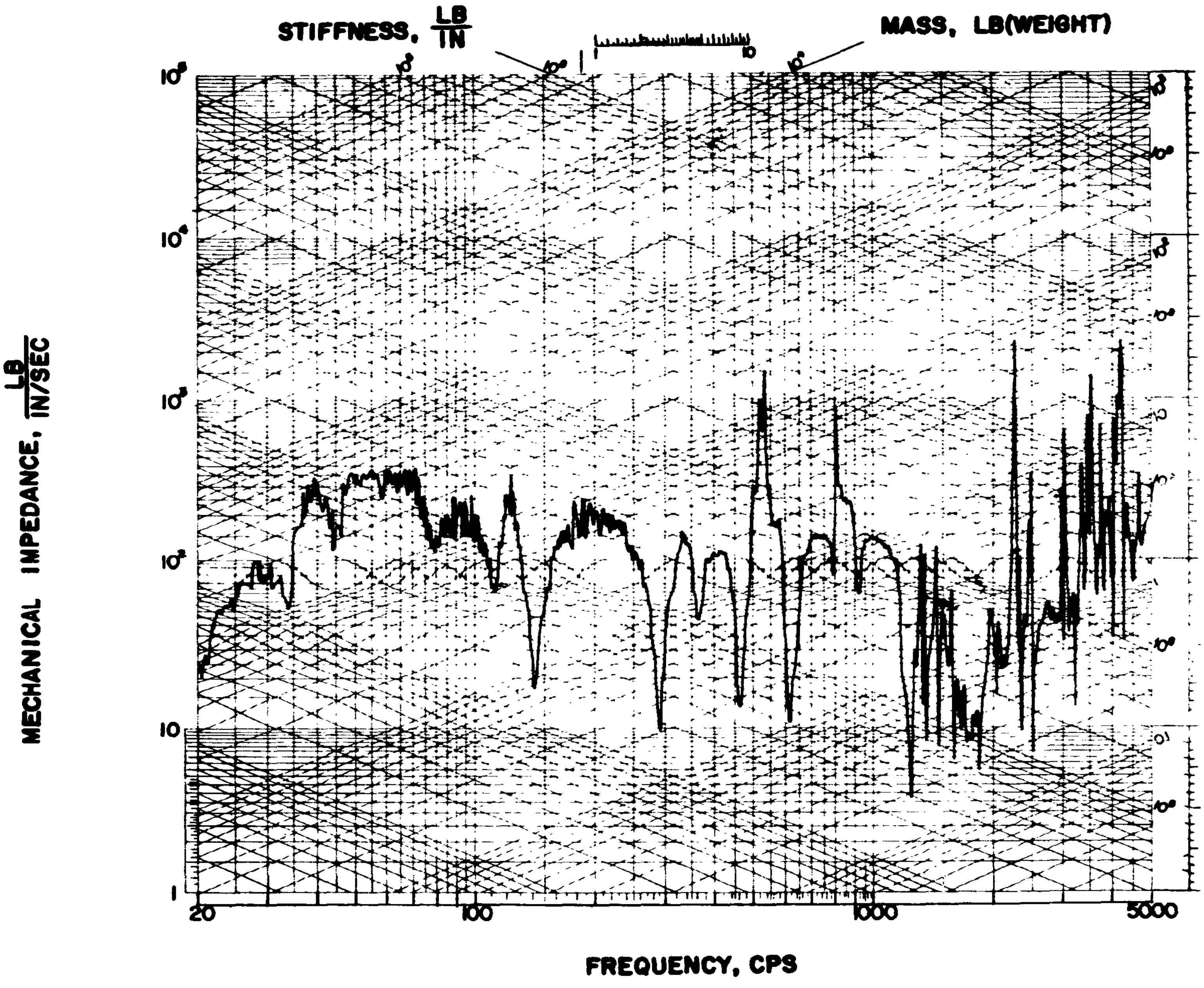
Z 22-23

PNS TEST T819 029

IND-PNS-1751 (NEW 5-62)

13

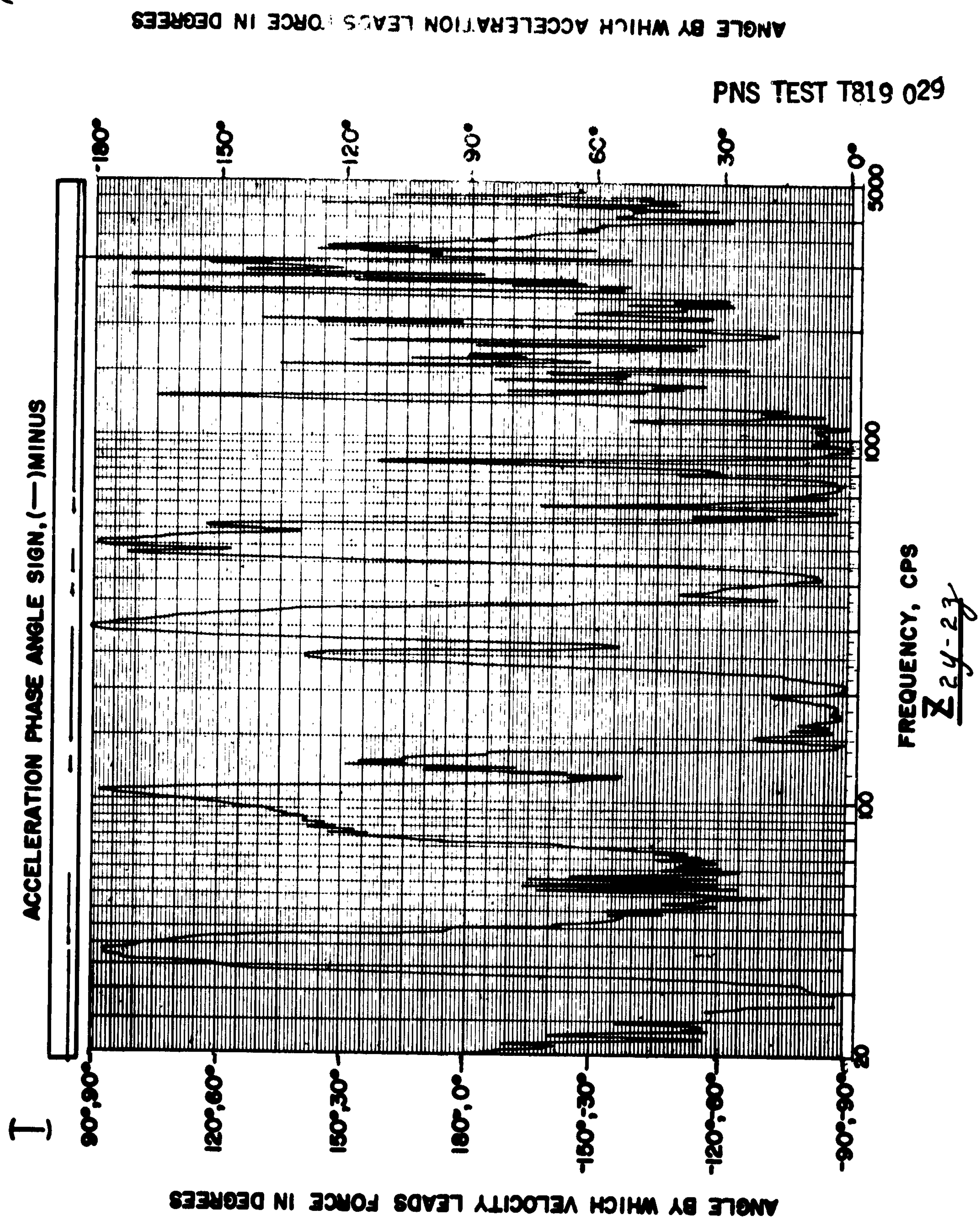
PNS TEST T819 029



Z 2y-2z

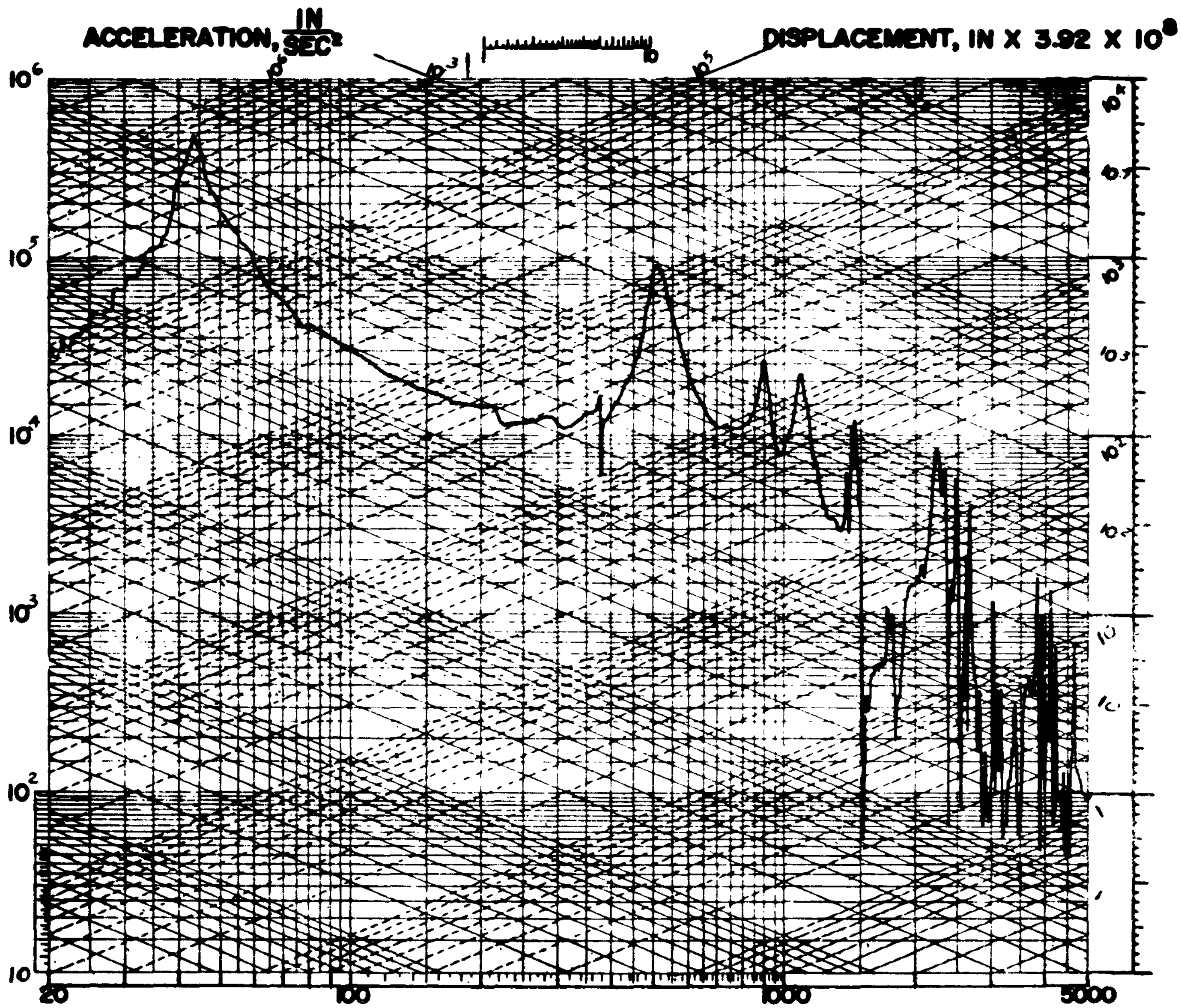
IND-PNS-1750 (NEW 5-62)

73



IND-PNS-1751 (NEW 5-62)

37
(X10)

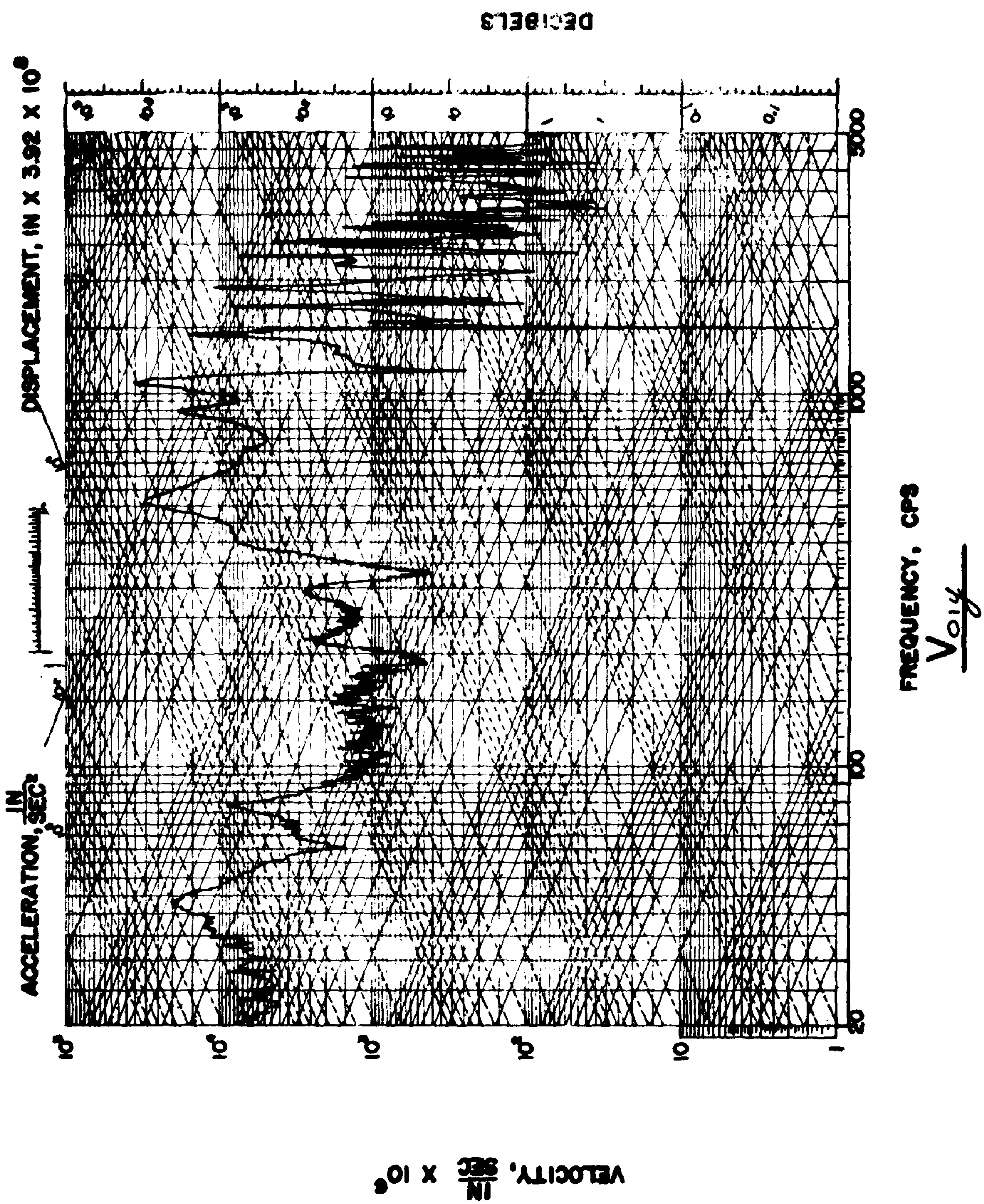


V_{01X}

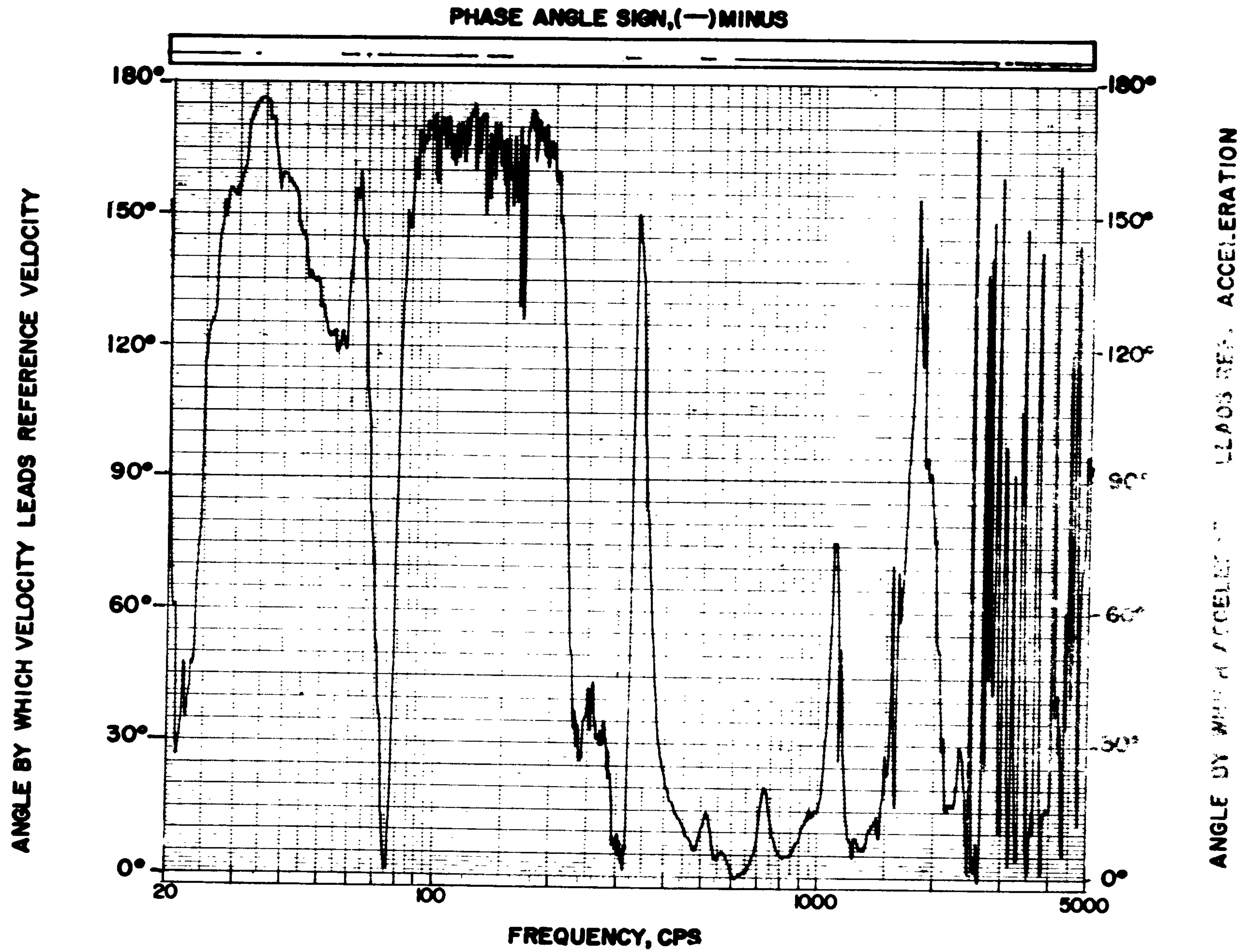
PNS TEST T819 029

IND - PNS - 1749 (NEW 5-62)

PNS TEST T819 029



38



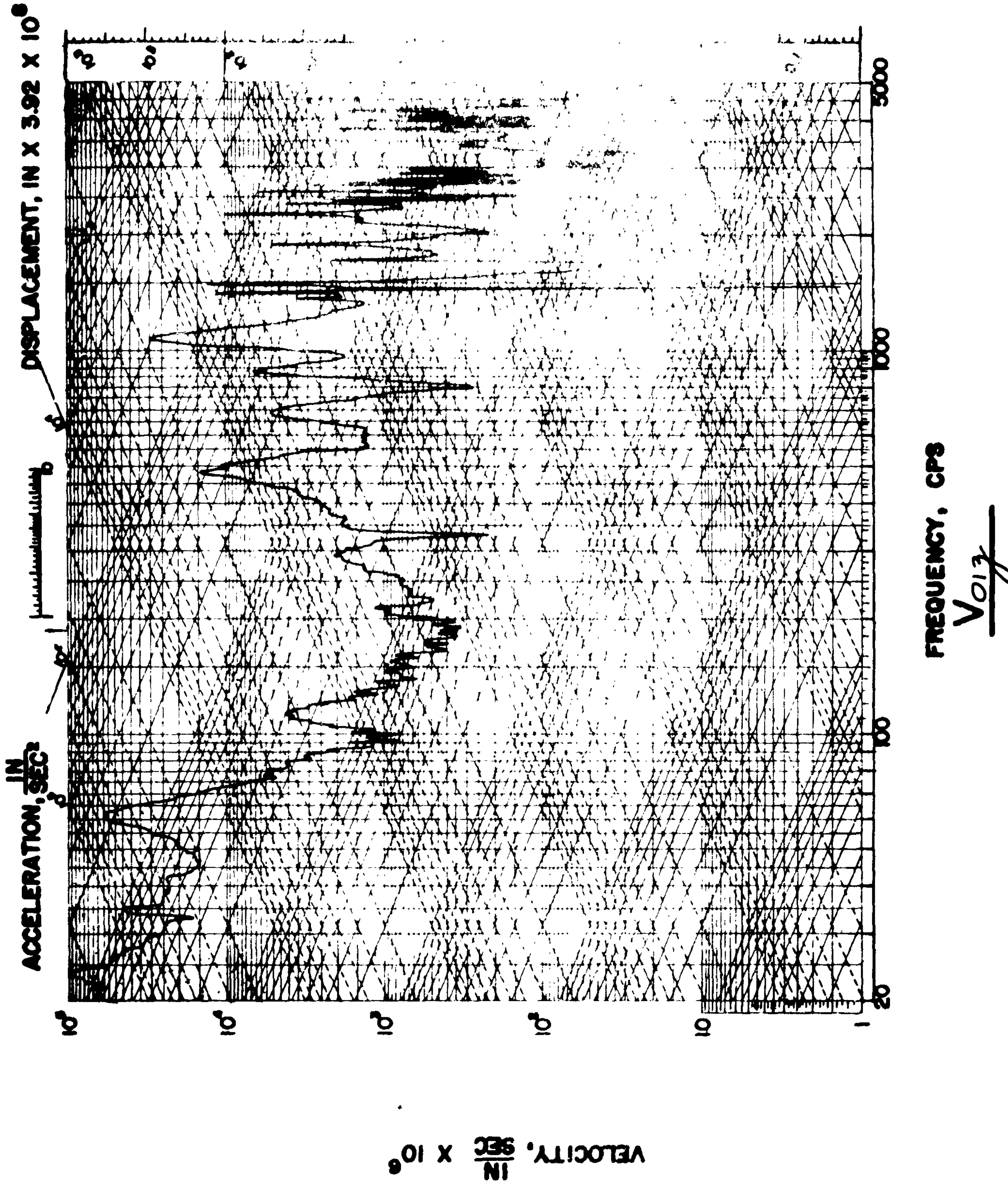
V_{oiy}

PNS TEST T819 029

IND - PNS - 1752 (NEW 5-62)

39

PNS TEST T819 028

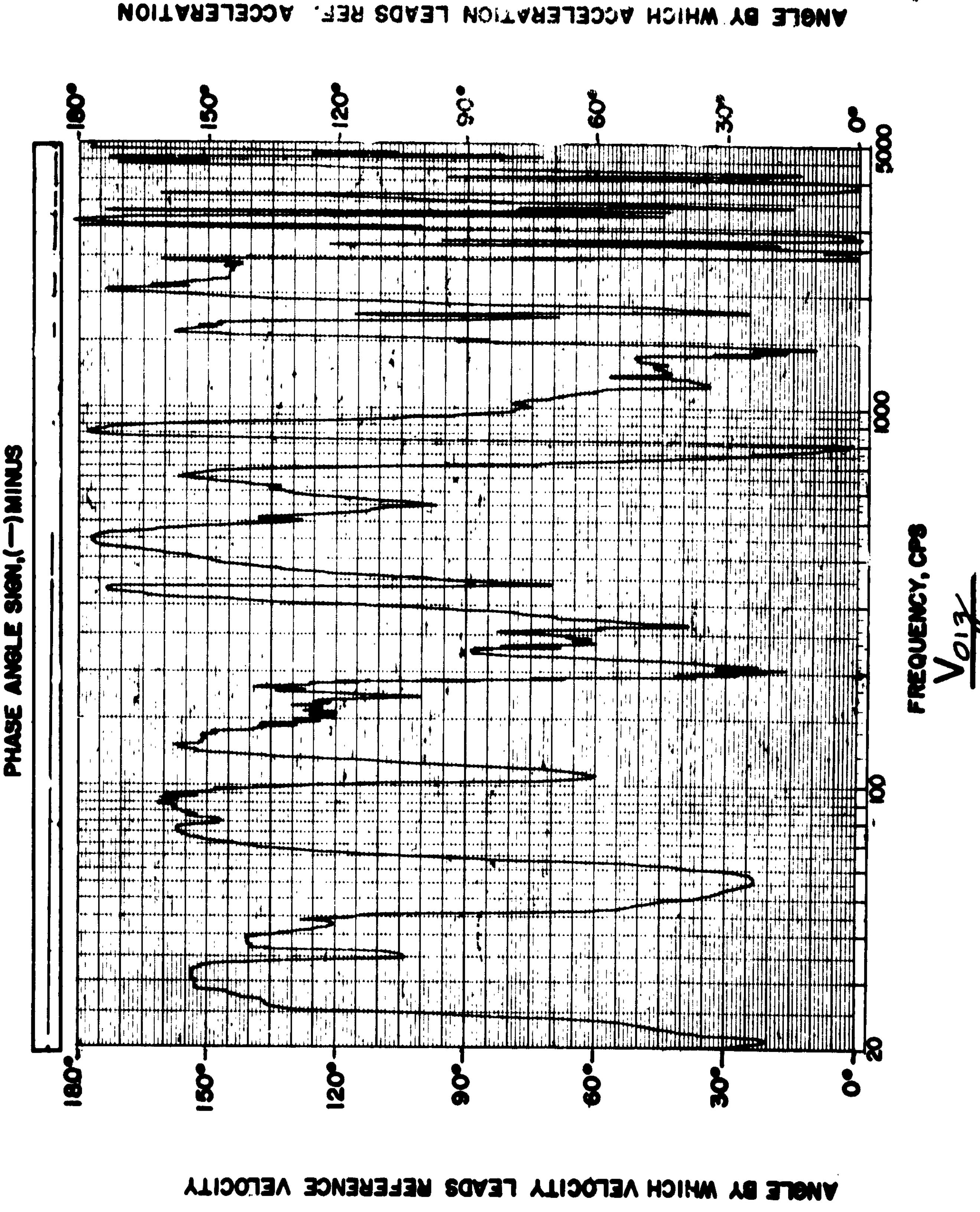


44

IND - PNS - 1749 (NEW 5-62)

39

PNS TEST T819 d29



IND – PNS – 1752 (NEW 8-62)